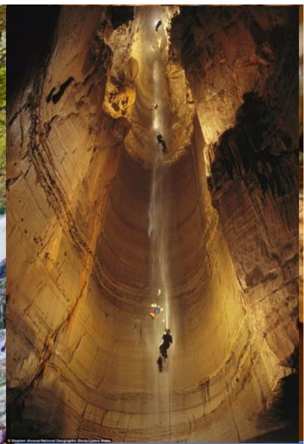
შოთა რუსთაველის საქართველოს ეროვნული სამეცნიერო ფონდი
SHOTA RUSTAVELI NATIONAL SCIENCE FOUNDATION OF GEORGIA

International Multidisciplinary Conference







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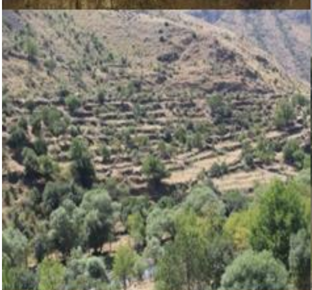




SEPTEMBER 9-13, 2019

TBILISI, GEORGIA

IVANE JAVAKHISHVILI TBILISI STATE UNIVERSITY

Actual Problems of Landscape Sciences:

Environment, Society, Politics

International Multidisciplinary Conference

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SEPTEMBER 9-13, 2019 TBILISI, GEORGIA

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PREFACE

The European Landscape Convention of the European Council entered in force in Georgia in January 1, 2011. Affiliating the Convention and thus undertaken obligation of protection, care, restoration and development of landscape showed the new understanding of the concept of landscape and the need for new approaches to research and education. Thatis why the collecting and understanding of different scientific concepts of landscape has come up in agenda in the context of the landscapes in theprism of the European Convention view, which considers landscapes as a field that people perceive, and the nature of which is determined by the action and interaction of natural and human factors. Along with the affiliating to the Convention, the country faced a new challenge to create a national strategy of landscapes, which should be unquestionably based on scientific research.

The European Council's almost all member states are affiliated to the European Landscape Convention and at present are at different stages of introduction of the Convention. Among the states that are not affiliated to the Convention, are Germany and Austria, however, they independently have their national policy of landscapes and the relevant regularities and the great experience of research in landscape sciences.

International multidisciplinary combined event "Actual Problems of Landscape Sciences: Environment, Society, Politics" to be held on September 9-13, 2019 at the Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia, recognizesthe ideals and values stated in the European Landscape Convention and responds toitschallenges, which emerged in Georgia before science, society or countrywith the accession to the Convention.

This international event combines natural, social, humanitarian and applieddirections and includes both,the Conference and Seasonal School.

The event will gather the scientistsfrom the countries accessionedto the European Landscape Convention and also from those countries, which have not ratified the Convention document so far but have a broadexperience in landscape studies.

The event objectives are as follows:

–To promote the dialogue on landscape surveys and exchange/shareknowledge and experience; to present achievements of Georgian scientists, their integration into the international scientific sphere and to strengthen the cooperation in order to prioritize future research surveys and develop innovative directions;

–To attract young people to science, represent young researchers, popularize the studies carried out by them and promote their professional growth in order to involve them in future international or local research projects;

–To represent the role of multidisciplinary approaches in landscape studies.

Assoc. Prof. Mariam Elizbarashvili,
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SHOTA RUSTAVELI NATIONAL SCIENCE FOUNDATION OF GEORGIA

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PLENARY SESSION

COMMUNICATING LANDSCAPE FUTURES FOR PARTICIPATION AND DECISION-MAKING

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Abstract

Planners and designers communicate their plans and designs within their own disciplines, to cognate disciplines involved in the relevant projects and also to the wider public and the lay people. It is typically assumed that the involved parties are able to understand what is communicated by the planning and design experts. However, the 'language' of planners and designers, i.e. plans, requires a certain level of expertise and understanding. There is a broad palette of technologies available to represent landscape futures. In recent years digital landscape representations showing the results of planning and design in perspective view have been widely used. These representations are typically shown as static visualizations or as animations at its best. While they may appear highly realistic, human perception is neither static nor is it fixed to a certain animated sequence. Humans perceive their environment in a dynamic way, and they also perceive the environment beyond the visual sense, including all the senses for a comprehensive sensory experience. There is a strong prospect that this limitation might be overcome by new developments in augmented reality permitting the user to experience landscape futures while on site and in the real multisensory world.

Key words: landscape planning, landscape visualization, sensory experiences, public participation, decisionmaking.

Introduction

In the planning and design disciplines in recent years there is a noticeable paradigm shift moving away from the traditional top-down approaches to a more inclusive bottom-up approach [1] in which planners and designers communicate their plans and designs to the general public. While in an ideal world this bottom-up process would lead to an iterative virtuous circle of how planning and design proposals are prepared, in practice limited project finances would not normally allow this, and also there is a certain limitation in terms of the willingness and interest of the general public to be involved on an ongoing basis [2]. Exceptions from this are highly political projects such as large-scale wind power projects, large-scale mineral extraction, hydropower projects etc. [3].

In addition to the requirement of communicating with the general public, planners and designers will also need to communicate with other disciplines including ecologists, geographers, biologists, civil engineers, transportation engineers etc. Similar to the language of planners and designers, other academic disciplines use their own expert language. E.g. while planners and designers typically communicate their ideas using graphics, engineers typically use mathematical formulae. In either case, when communicating beyond one's own discipline or when communicating, to the general public a certain level of expertise and understanding is essential.

Human perception of their environment

Humans possess a range of senses that they use to sense their environments. These include an auditive, tactile, kinaesthetic, vestibulary, olfactory, gustatory and visual system. By far the most dominant sense is the visual sense [4]. There are of course atypical situations in which a certain stimulus might overwhelmingly influence all other sensory experiences such as in a smelly landscape where manure is spread or loud noise generated e.g. through heavy traffic. The dominance of the visual sense is represented in our everyday language, such as in expressions like 'what you see is what you get' or 'a picture is worth a thousand words'. Unlike in a static framed picture the world is not static and neither are the people moving through the real world. The environmental psychologist Gibson highlighted this issue in his theory of ecological perception [5], in essence stating that human perception is a dynamic process in which it is key perceiving the environment while moving through it.

Landscape representation for communication

There is a very long tradition of how to represent landscapes. Techniques include physical models, freehand drawings, constructed perspectives, etc. to name just a few.

In planning and design practice and research in most cases only visual representations are used for communicating with experts and lay people. Typically, these approaches will exclude other sensory stimuli. Recently, the effect of sound on the visual representation has been a subject of research [6]. Depending on the source of sound (noise) and whether it is artificial or natural it can have a negative or positive effect on the overall perception.

In Switzerland, a simple but effective method for showing new built form is required by the planning law. Any new building has to be visualized through wooden structures or aluminium poles indicating the extent of the proposal (Fig. 1). This approach makes sure that the involved citizens are made aware of any planning proposals well ahead of construction and are thus able to raise their concerns in order to get involved in the decision-making process.

Fig. 1 Existing situation and on-site visualization of a proposed new housing development in Switzerland by using aluminium poles to indicate the extent of the project.

With advances in representing realism through visualizations it is now possible to visualize highly realistic scenes. However, this does not mean that the depicted realism is a true reflection of what might be the reality of the future. Even wrong data or a lack of detail in the data would still allow generating a scene that could look highly realistic. In this sense, one does not always see what one gets [7].

Fig. 2. Ex-ante visualization of Edward Street Park in Sheffield and the corresponding viewpoint after constructio (see [8]).

Visualizations such as the one of Edward Street Park (Fig. 2) can also be experienced through real-time movement within the virtual environment. This comes relatively close to what Gibson expressed in his

theory of ecological perception **[5].** Yet, given the limitations in terms of sensory experience it is still a visual abstraction of a multi-sensory environment. From a decision-making perspective a dynamic, navigable virtual environment is superior to a static representation [9]. A combination of a real-time navigable environment with a plan view has proven to be even more effective for communicating proposed futures and facilitating discussions among experts (see **[**10]).
While normally virtual landscape models (of which there is a constantly growing number) are experienced in an indoor laboratory environment, Gill and Lange **[**11**]** developed a system that would at the same time allow to view and navigate through the same model while being on site (Fig. 3).

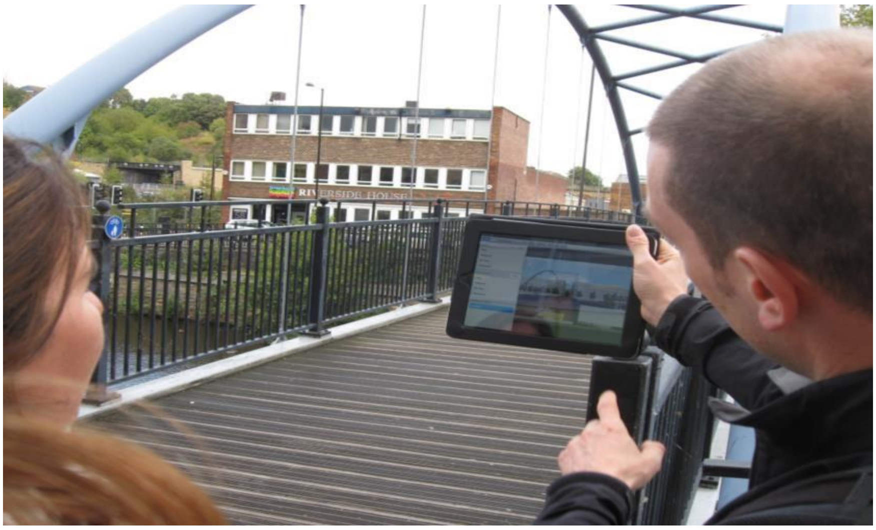

Fig. 3. Mobile device linked to a remote server allowing real-time display of the virtual landscape model.

By operating a specifically developed user interface a remote server, e.g. placed in a laboratory, is running the virtual landscape model and allows the visualization to be displayed on a mobile device such as a mobile phone or tablet PC
Rather than visualizing entire virtual environments Augmented Reality allows to overlay specific information or graphics onto a real world scene as seen through the lens of a mobile device [12] (Fig. 4).

Fig. 4. Augmented Reality for visualization of flood levels. The blue plane displayed in the mobile phone shows the possible extent of the flooding. At the same time the white cube (i) allows the user to click and get real-time flooding information provided by a flood sensor.

Conclusions

Due its complexity and the multi-sensory dimension it is nearly impossible to simulate a realistic representation of our environment. We have to accept that we have to work with a certain level of abstraction when communicating landscapes and landscape futures to stakeholders involved in planning and design of our environments. Unlike in a laboratory environment that is geographically separate from the real world, simulated in the laboratory, new developments in augmented reality allow to simulate possible changes while being on site. Still mostly in its infancy and in the early stages of being applied to real-world planning and design contexts this approach offers huge potential in providing not only a visual experience but also a multisensory experience while being on site.

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GEORGIAN LANDSCAPE SCHOOL: HISTORY, METHODOLOGY AND OPPORTUNITIES

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Abstract:
Landscape science is not only a fundamental, but also applied science, which studies natural-territorial complexes (NTC), genesis, territorial distribution, development and dynamics. Such researches should become the basis of rational use and effective management of natural resources, territorial planning, estimation, monitoring, forecasting and protection of the environment.

The goal of the study is to show the principal trends in the formation and development of the Georgian school of landscape and approaches and role it has played in the development of landscape studies and geography in general. A very important phase in the development of the landscape studies in Georgia was 1980s, when the concept of spatial and time analysis and synthesis of the natural-territorial complexes was developed at Tbilisi State University under the leadership of Professor N. Beruchashvili. Since then, a number of scientific works of great theoretical and practical value have been written.

The study has revealed the principal stages and trends of the development of the Georgian landscape school, as well as theoretical and practical results. The scientific works of an applied nature have demonstrated that they are based on fundamental studies, and the landscape maps are widely used for this purpose. Besides, at present, the landscape studies have shifted from the phase of inventory to the phase of evaluation and territorial planning.

Key words: Landscape studies, NTCs, Georgia.

Introduction

The precondition for sustainable development of any countries is connected not only with the adoption of correct political, economic, social decisions, but also with their orientation on the fundamental scientific base. In this respect, an important role belongs to landscape science. It is a complex science which deals with the analysis and prognostication of both natural and socio-economic processes, as well as spatial - temporary features of interdependence of man and nature.

At the present stage of societal development, the interest towards the constructive scientific branches is constantly increasing. Landscape science is not only a fundamental, but also applied science which studies natural-territorial complexes (NTC), conditions of their formation, territorial distribution, development and dynamics. NTCs are complex dynamic systems which consist of separate, but closely connected components. The integrated researches should become the basis of rational use and effective management of natural resources, territorial planning, estimation, monitoring, forecasting and protection of the environment. All the issues set forth above are the basic problems of geography, the decision of which demands complex research of the environment, determination of present-day condition and trends, resource potential, stability, critical areas, degree of anthropogenic transformation and maximum allowable anthropogenic pressure.

In recent years, the interest in landscape studies has been particularly keen. This is evidenced by the fact of using this term in the legislative documents. For example, in 2000, the European Landscape Convention was adopted in Florence. Under the Convention, a landscape is understood as a natural resource and an object of territorial planning and management and trans-boundary cooperation playing a great role in the cultural, ecological, environmental protection and social fields of the society, being a beneficial resource to manage and plan the economic activity [1]. It is true that the landscape here is not understood as a territorial unit formed through the deep complex mutual links between the natural components, but rather a territory perceived by people. However, it is important to note that the nature of perception by people is explained through the mutual impact between the natural and anthropogenic factors. This definition goes beyond the view of the landscapes as sceneries and gets close to the complex understanding of the landscapes. In recent years, the landscape has been considered as one of the most important objects of the studies of the natural resource management and land use what is evidenced by the studies in the field of landscape planning and landscape-ecological zoning [2].

The goal of the study is to show the principal trends in the formation and development of the Georgian school of landscape and approaches and role it has played in the development of landscape studies and geography in general.

Results and discussions

Term "Landscape" in Georgian literary sources

It is commonly known that word "Landscape" comes from German (Landschaft - „Land"; „schaft"– "View") and means a scenery, view of the land. This word appeared in Europe several centuries ago. As far back as in the IX century, the word was referred to in the writings of the monks of the St. Boniface's (Fulda) Abbey (Germany). As another view suggests, the word was used with a different orthography (*landscipe* or *landscaef*) in England as early as in the V century, after the Anglo-Saxons started their settlements there. Clearly, this word changed its original meaning and in the XIX century, it appeared in the geographical surveys, as well.

In Georgian literary sources, word "Landscape" appeared in the middle of XIX century by Ilia Chavchavadze **[3]**. It is noteworthy that the study does not only mention the landscape, but also gives a kind of its definition. Clearly, it is understood as scenery and its change is realized in concordance with the location change of the observer: "In reality, every field is subject to the laws of space and time... Yes, you see a wonderful picture on the land in the concrete place (landscape), but how? – Surely, from far afield and from one point, from one point of examination at the same time: the far distance gives the landscape the beauty of painting; the examination point, from which you are observing the landscape, gives it the unity and wholeness. Just make one step, change the observation point and the landscape will disappear: you will see only some discordant and endlessly scattered area without any unity or type...". This word was mentioned also at the beginning of the XX century. In 1907, newspaper "Chveni Gza" ("Our Way") mentions "historical landscape" in relation to Czechia [4]. It is interesting that in the 1920s term "landscape architecture" appeared in Georgian periodicals in relation to growing gardens and parks in Tbilisi [5, 6].

Issues of studying the landscapes of Georgia

Every scientific discipline has certain scientific premises of its development. For landscape studies, this function was played by the development of the branch-geographical and intersectorial disciplines. Particularly important was the shift from the analytical to the synthetic method.

V. Dokuchaev was considered as one of the founders of the landscape studies; however, it was not him introducing this term. He created the science about soils, though considered the soil in a close relationship with other components of nature and thought that the soil was originated as a result of such relationships. Dokuchaev concluded that it was necessary to create a new science about the relations between the living and non-living components of the nature. He did not give a name to the new science; however, he laid the foundation to the doctrine about landscapes. This is why he is considered a founder of landscape studies [7]. Finally, a classical understanding of the landscape was given by A. Berg, who considered it as a natural region, where the relief, climate, vegetation and soil cover form a harmonious unity and typically appear at different locations of the Earth.

The 1950-1960s are termed as the "Golden Age" in the history of development of the landscape studies. In this period, three different trends developed, which differ from one another with different interpretations of the landscape. This period is marked by the development of landscape studies in Georgia.

The first landscape studies in Georgia are associated with the name of Georgian geographer, Academician of the Georgian Academy of Sciences (1944), President of the Geographical Society of Georgia (1940-1070), Merited Scientist of Science of Georgia, Professor *Alexander Javakhishvili* (18751973). He gave the classification of the (types) of landscapes of Georgia and identified natural and cultural landscapes. As early as in 1935, he developed a curriculum in landscape studies for the university. Besides, on the example of description of the landscapes in Kobuleti and Makharadze regions, in 1937-1938, he developed the samples regional complex survey in physical geography [8].

In the following period, the landscape studies in Georgia developed mostly in the direction of landscape morphology (D. Ukleba, M. Saneblidze, Qr. Jakeli, et al).

A very important phase in the development of the landscape studies in Georgia was 1980s, when the concept of spatial and time analysis and synthesis of the natural-territorial complexes was developed at Tbilisi State University (Martkopi Physical-Geographical Station, Laboratory to Study the State of the Environment with Aero-Space Methods) under the leadership of Professor *N. Beruchashvili* [9]. Since then, a number of scientific works of great theoretical and practical value have been written, which are based on stationary, semi-stationary and expedition and remote survey methods. The major value of the methods is the opportunity to study the natural components, state of NTCs, peculiarities of structure and operation, modern state of the landscapes and degree of anthropogenic transformation with the methodological basis, develop prognostic spatial and time models of the NTCs, etc. Many mountainous regions in the world (Altai, the Carpathians, Khibiny Mountains, the Alps, etc.) are studied by using these methods.

Landscape studies have been developed in several directions in Georgia: landscape geophysics, landscape ethology, landscape ecology, landscape planning. Landscape geophysics is a discipline of landscape studies, which studies general physical properties of the NTCs and processes and events occurring in them (e.g. issues of substance rotation and transformation), i.e. the field of study of landscape geophysics incorporates all common processes and phenomena of the functions taking place with NTCs [10]. So, quite fairly, the French science school named it a discipline about the physical and biological fundamentals of the environmental dynamics, while Armand called it a doctrine of the physical interaction between the landscape components.

They divide the history of development of the landscape science into 3 periods [9]:

The I period (XIX c.-1940s) was associated with the development of the concept of landscape studies. In this period, a system of views, which must create a certain direction in the study, was not identified yet and a concept about the NTCs was developed.

In the II period (1945-1964), landscape study was established as a science and academic subject area.

In the III period (from 1965 to present), new scientific directions of the landscape study were developed such as landscape geophysics, landscape geochemistry, landscape ethology, landscape ecology, etc. During this period a lot of field works were conducted in different landscapes of Georgia. The study was carried out by Tbilisi State University Scientific-research LAB in 1977- 2005. The author personally participated in the collection of field materials. These field plots cover the entire spectrum of Georgia's landscapes from plains to high mountain alpine and subnival landscapes. The field studies involved absolute majority of Georgia's landscapes (9 out of 14 types of landscapes spread in Georgia, 17 out of 22 subtypes and 41 out of 71 genera).

The description of field plots was carried out in different places of Georgia [11]: Lagodekhi (1977), lake Amtkeli (1982), Khaishi (1984, 1991), Bakuriani (1986), Grigoleti (1989), Ambrolauri (2000), Borjomi (2000), Lentekhi (2004), Gagra Range (1980, 1986), Racha Range (1982), Shoda – Kedela Range (1983), Gardabani plain (1981), Dzama valley (1981, 1985), Duruji valley (1981), Alazani - Pankisi (1987), Algeti (1986), Patara Liakhvi (1986), Bjoliskhevi (1989), Pshavis Aragvi and Khevsuretis Aragvi (1982), Askhi (1982), Guria (1983), Ajara (2005), Kovaluki hill (1982, 1985), the upper stream of Dighmistskali (1986, 1987, 1992), the Rioni basin (1988), vicinities of Martkopi and Ialno Range (1975, 1987, 1993) (Fig. 1).

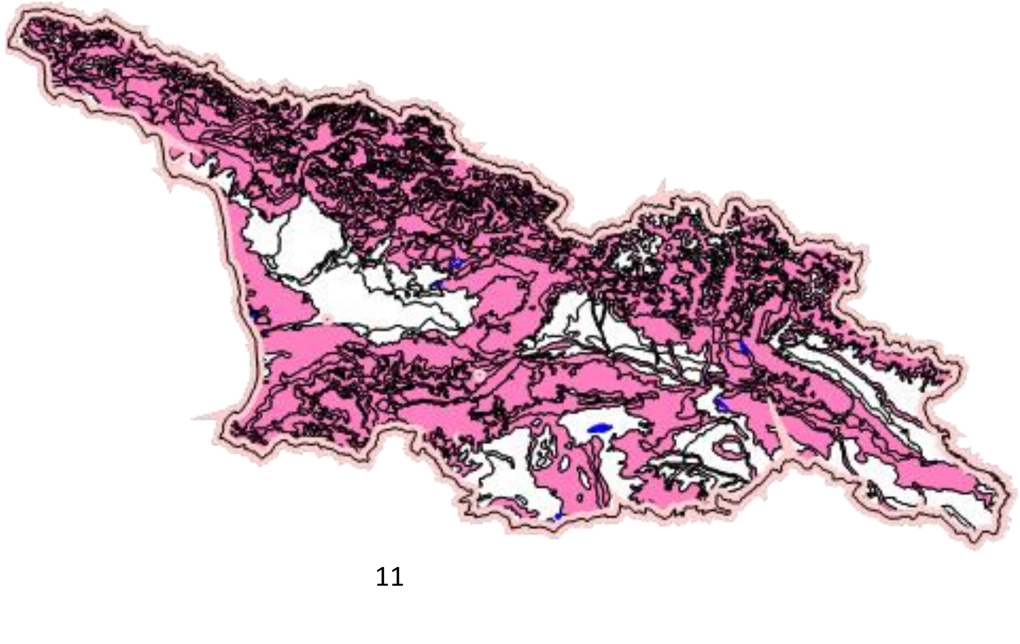

Fig. 1. Field works in landscapes carried out in the different regions of Georgia

In this respect, the analysis of to what extent Georgia's territory has been studied has shown that mountain landscapes are better investigated than plain landscapes. Completely opposite picture is observed in the sphere of physical-geographical research. It is determined by the following factors: a) the majority of physical-geographical stations (meteorological, hydrological) are located within the limits of the plain and foothills, whereas they constitute only 11 % of field expedition plots; b) the only physical-geographical stationary in Georgia is located within the limits of the plain; c) landscape- geophysical research techniques of NTC is mostly oriented to and approved for mountain territories. High-mountain landscapes are less studied. It refers not only to subnival and nival, but also to sub-alpine and alpine meadows. It is caused, probably, by the fact that during the research the main accent was always allocated on NTC (and in Georgia the majority of woodland areas are located within the limits of mountains). It is also testified by the multitude of experimental plots – forests NTC constitute 87 % out of the total number [11].

As for the individual regions of Georgia, the situation is also much diverse with them. The environs of Martkopi station and Ialno Range are studied best of all [12, 13, 14, 15, 16, 17]. Most of the papers are based on the data of two research stations (Martkopi station, or "Lower Base" and Ialno Range, or "Upper Base") and 6 experimental plots (found within the limits of the hilly steppe landscape of the piedmont), in particular, on the information about the state of geo-systems, course of their annual cycle and characteristics describing this state.

The field plots are distributed almost evenly between west and east Georgia; however, there is a difference between the areas of plane and mountain landscapes in this respect. The regions of Georgia also differ much from one another. The majority of the experimental plots (17%) are found in Racha-Lechkhumi-Kvemo Svaneti, while their least number (2%) is found in Guria (Fig. 2).

The geophysical analysis of the landscapes of the Lesser Caucasus to identify the system of protected areas and degree of diversity of the landscapes is considered in the work by N. Jamaspishvili [18]. This work is an attempt to identify the favorable sites for the ecological corridors and protected areas by using a landscape-based approach.

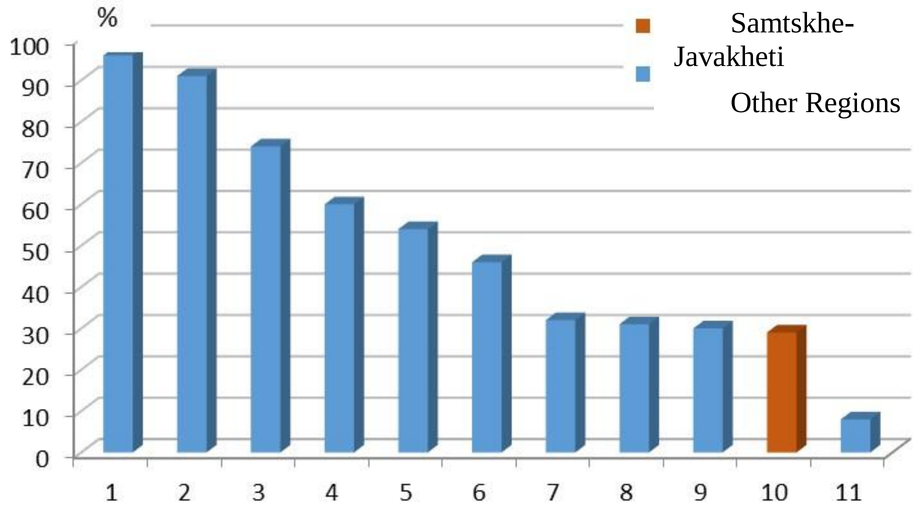

Fig. 2. Distribution of experimental plots in the regions of Georgia

The landscapes of Georgia are studied quite well by Georgian and foreign geographers, both, at the level of their individual components and as a whole complex. However, there is still much to study. The geographical literary fund offers only few works giving a landscape or landscape-geographical or landscape-ethological analysis of large regional units. The same is true for the landscapes of Georgia. However, there are important works highlighting the physical-geographical, landscape-geophysical and landscape-ethological properties of the landscapes of Georgia.

The landscapes of the Caucasus, including those of Georgia are considered in a single view and quite thoroughly in monograph "The Caucasus: Landscapes, Models, Experiments" [19] giving the landscape-geophysical and landscape-ethological properties mainly at the level of landscape sub-types, certain landscape “groups” or dominating types of the vertical structure of the natural-territorial complexes. The monograph gives less consideration to geomasses, various landscape-geophysical properties and analysis of the correlation between the physical-geographical factors.

Mountain landscapes are studied much better than plain landscapes. The picture is absolutely different in respect of a physical-geographical study. The reasons for such state of affairs are as follows: a) most of the (meteorological, hydrological) stations needed for the physical-geographical analysis of the territories are located on the plains or piedmonts giving only 11% of the landscape-geographical description of the field and expedition plots, b) the only physical-geographical station of Georgia is located on a plain. It is true that the results of the regular studies accomplished in the environs of the station (Ialno) may be generalized for most mountain landscapes in East Georgia, but this will be an insufficient measure anyway, moreover for a large-scale detailed study, c) the methods of the landscape-geophysical study of NTCs is more oriented on and approved for the study of the mountainous areas. The degree of study of the mountain landscapes also varies within great ranges. Some landscapes of Georgia, such as middle-mountain forest landscapes of the Caucasus with dominant beech forests were treated as a subject of an individual study [11] considering some landscape-geophysical and landscape-ethological properties, as well as anthropogenic transformation of the territories and other issues. The upper mountain forest landscapes of the Caucasus are also studied [20].

This work gives the physical-geographical factors of formation of the given landscapes and quite a detailed analysis of the major landscape-geophysical properties. The natural-agrarian territorial complexes of Georgia and their locations were among the study objects [21, 22]. The analysis of the quality of the geophysical study of the landscapes of Georgia has made it clear that the high-mountain landscapes are studied the least. This is true for not only subnival and nival, but subalpine and alpine meadows as well. However, there are some works [23] considering individual issues of landscape geophysics.

The issues of the vertical structure of the natural-territorial complexes of the Caucasus are studied quite well {9, 10, 19]. Some works consider such a structure during the summer stex of the stabilization of a phytogenic structure [24], while other works consider it on the background of an annual cycle. These works consider both, the general and regional issues of the vertical structure of the landscapes. The issues of daily states of the underground part of the natural-territorial complexes are considered in the work by R. Maghlakelidze [25]. Much attention is paid to the identification of the major properties of daily states of the soil, the pedostexes, and borders of a stex layer, vertical structure and bio-geo-cycle of a natural-territorial complex. The issues of solar energy transformation in Martkopi environs are described in the work by T. Jibladze [26]. The work considers the issue about the distribution of solar energy in different periods of the year and for different morphological units of the landscape. The questions of studying and modeling the climatic processes taking place in the landscapes of the Caucasus are considered in the work by M. Elizbarashvili [27]. Based on the analysis of the standard meteorological data and by using the quantitative methods, the climate-resource potential of the landscapes are assessed in the area, their transformation plan and criteria are developed (expressed as values of air temperature and atmospheric precipitations) and the response of the local climates to the global warming (warming, desertification, air temperature anomalies) is given here. As for the high-mountain subnival and nival landscapes, the climatic regime of the landscapes is modeled for them.

Based on the analysis of physical-geographical semi-stationery observations, the areas of Amtkeli Lake and Kovaluki Plateau are studied [28, 29, 30, 31]. These studies are mainly focused on the issues of seasonal dynamics of the natural-territorial complexes. The study of the environs of Kovaluki Plateau [30] is based on semi-stationery observations carried out in 1981-1989 within the limits of humid subtropical Kolkheti (piedmont hilly) landscapes. Besides the landscape-geophysical and landscape-ethological analysis, the work also gives the semi-stationary concepts of Kovuluki for 10 main parameters of the natural-territorial complexes. As for the study of Amtkeli Lake environs [32], it is mostly a landscape-geophysical analysis of the plain area, lower mountain forest and middle mountain forest landscapes in the given area. The issues of structure and dynamics of the natural-territorial complexes, relations between the individual geo-masses and index of intensity of the biological circulation are studied.

The landscape-ethological situations and scenarios of Georgia and other mountainous areas (Khibiny Mountains, Chechnya-Ingushetia, Tanu-Ola Ridge, Crimean Mountains) are considered in the work by T. Gordeziani [33]. Svaneti and Dzama gorge were selected as model areas for the territory of Georgia. The main goal of the given work was to develop the theoretical basics of mapping the state of the natural territorial complexes. The main accent was made on the issues of cartographic forms of the time synthesis, abstraction and generalization of the given states.

Of the landscape-geophysical properties, the phyto-masses are studied the best by various works, including the works giving the analysis of the phyto-masses not only on some territories, but also on the landscapes of all the Caucasus and Georgia [34, 35, 36].

Concept of the landscape – different views at Georgian school of landscape.

The landscape classification has not only theoretical, nut also the practical value. It allows grouping similar landscapes and evaluating them in respect of territorial planning, resort and recreational, agricultural management, melioration nature use, etc. Therefore, the issues of landscape classification were paid much attention and intense discussions were held in relation to this issue.

A number of scientific works have been dedicated to the issues of landscape classification. These works give different views about the principles and methods of the landscape classification depending on the essence and various parameters of the landscapes. There are various views regarding both, the general and the individual classification of the landscapes.

Generally, there have been three kinds of landscape concept established: general, typological and regional. Landscape, **as a general concept**, is perceived as a synonym of a natural-territorial complex. Therefore, landscape may be considered in different ranks and we can talk equally about the plain, desert or forest landscapes, as well as Tbilisi basin, Kolkheti Valley, African, hilly or erosive landscapes. Such an approach much complicates the classification of landscapes and gives it as a general ranking unit. Virtually, this view never had any supporters in Georgia.

Unlike the general view, **a typological concept** of a landscape had much more supporters in Georgia: D. Ukleba, Kr. Jakeli, M. Saneblidze and others. A landscape as a typological unit means that it is regularly repeatable in time and space, i.e. the same landscape may be found at different locations at the same time. For instance, marsh, valley and desert landscapes are spread at different locations at the same time. Consequently, many areas greatly distanced from one another (even found on different continents) may belong to a single type of a landscape. Grouping them as a single unit is possible by considering the similarity of the principal properties of their natural conditions. Unlike the former concept of the landscape, with the given type of landscapes, a geographical (territorial) appropriation is shown in the name of the landscape if it (the geographical object) has certain general properties distinguishing it from other objects. Therefore, they commonly talk about the landscapes not of Caucasus or Georgia, but of Kolkheti. The latter is really distinguished for its unique features. Based on the typological concept of the landscapes, there are two landscape maps compiled for Georgia: a landscape map of Georgia scaled 1:600 000 [37] and a landscape map of Transcaucasia, scaled 1:600 000 [38].

A regional plan of the landscape considers the landscape in an unrepeated unit of time and space, i.e. the landscape is spread at a single location only at one-time moment and is a concrete area, which is a single unit with its genesis, history of development and natural conditions. For example, the landscapes of Tbilisi basin are typical for Tbilisi environs only, but this does not mean that it is impossible to find any similar landscape in some other area. At the same time, similar landscapes may be found at different places, but they are considered only as analogs, object-analogs or analog-landscapes, not as the same landscapes. When we talk about analogs, they accent the essential and main issue, but overlook a great many other unique features.

A landscape “focuses” on the regional and typological properties of the nature at the same time. This is why it is necessary to consider this circumstance during the landscape classification. The supporters of a regional concept of a landscape consider that the consideration of the typological peculiarities must be done by comparing the classification units of the landscapes at a lower level. This view more dominates in the landscape studies. The precondition for establishing such a view was developed by L. Berg when he noted that each landscape is unique in time and space. His supporters are N. Beruchashvili and the representatives of the landscape school established by him.

Different views regarding the anthropogenic transformation of the landscapes

A number of works have been dedicated to the anthropogenic transformation of the landscapes and relevant classification issues. The works show quite rigorous discussions between the researchers regarding the identification of the essence of the landscapes. Finally, two major views were established: the first view suggests that the scales of the anthropogenic transformation are so great that this event may be compared to the natural processes in this respect. Academician V. Vernadskyi wrote that the anthropogenic changes of the nature have affected our planet no less than the geological processes. Consequently, the supporters of this view considered that one can talk about anthropogenic landscapes as well. Such a view is based on the concept that it is absolutely sufficient to change even one landscape component (e.g. soil or fauna) to make the landscape anthropogenic [39, 40].

An absolutely different opinion was expressed by the supporters of the second view [41, 42]. They think that as a landscape is a complex structure and is a system of interacting and mutually determining components, a change of one component only not followed by any essential change of the whole complex cannot be considered a fact of an anthropogenic change of the given landscape. What the supporters of the first view think of an anthropogenic landscape, the supporters of the second view consider as anthropogenic modifications. Therefore, the use of terms “residential landscape”, “industrial landscape”, etc. is not considered expedient. They more concern the general view of the landscape [42].

Besides, the supporters of the second view confirm another view suggesting that the anthropogenic changes have more or less affected the whole landscape layer and today and there are no landscapes on the Earth without some direct or indirect human impacts. Therefore, differentiating between the “natural” and “anthropogenic” landscapes is rather conventional. Similarly, difficult is to identify the limit between these two landscapes. The major reason to ignore the previous view is the natural regularities continuing to act in both cases [42].

The supporters of the existence of the anthropogenic landscapes from Georgian school are the supporters of a typological concept of a landscape, while the supporters of the absence of the anthropogenic landscapes are those sharing the regional concept.

What is done?

Outcome 1.There is done some landscape maps of Georgia:

- Beruchashvili N. Landscape map of Caucasus: Types of NTCs, 1983, Fund material. scale 1:500,000 [43];
- Beruchashvili N. Landscape map of Georgia, Tbilisi: National Atlas of Georgia, 2009, scale 1:1,000,000 [44];
- Saneblidze M., Ukleba D., Djakeli K. Landscape map of Georgia, Tbilisi, 2009, scale 1:600,000 [45];
- Djakeli K. Landscape map of Georgia, Tbilisi-Moscow: Atlas of Georgia, 1964, scale 1:1,500,000 [46];
- Beruchashvili N. Landscape map of Caucasus. Tbilisi, 1979, scale 1:1,000,000 [47];
- Ukleba D. Landscape map of Transcaucasia, Tbilisi, 2009, scale 1:600,000 [48];
- Nikolaishvili D. Landsacpe map of Georgia. // Geographical atlas of Georgia, 2018; scale 2,000,000, pp. 70-71 [49]; etc.

The landscape map of Georgia [43, 44] is based on the regional concept of landscapes. However, at a higher (e.g. typological) level of the classification units, the typological understanding of the landscapes must be considered as well.

According to this map, there are 2 classes, 14 types, 22 sub-types and 71 genera of landscape identified on the territory of Georgia:

Landscape class is the largest classification unit of a landscape identified based on a hypsometric factor. There are two landscape classes: mountain and plane landscapes. By considering the hypsometric and morphological factors, the piedmont hilly landscapes belong to plane landscapes, while high mountain upland regions and plateaus are mountain landscapes. ***A landscape sub-class*** is identified based on the changing zonal-sectoral peculiarities at various absolute altitudes. The mountain landscapes are divided into high, average and low mountain landscapes, while the plane landscapes are classified as plane-lowland and hilly landscapes. The mentioned map does not give a landscape sub-class as a separate unit. ***A landscape type*** unites landscapes with the same type of hydrometeorological conditions, common structure, same biological indices and same regime of chemical elements migration. As such important processes of landscape functioning, as moisture turnover, bio-geo-cycle and soil formation result from by the warmth and moisture supply, in identifying a landscape type, the primary importance is given to the hydrothermal regime. According to the thermal conditions, they identify 5 types of climate on the territory of Georgia: subtropical, moderately warm, moderate, moderately cold and cold, and 6 types of climate depending on humidity: humid, semi-humid, semi-arid, arid, sub-Mediterranean and hydromorphic. Consequently, there are 14 landscape types on the territory of Georgia (Fig. 1). ***A landscape sub-type*** is identified based on the secondary zonal and sectoral peculiarities of the hydrothermal conditions. For example, 2 sub-types are identified in moderately cold mountain landscapes: 1) the Middle Mountainous landscape (with dark coniferous forest), and (2) Upper mountain landscape (with birch and pine forest). There are 23 sub-types of landscape in Georgia. ***A landscape genus*** is the smallest classification unit in the given map characterized by one type of a relief and one or dominating geological and plant formation. Within the borders of Georgia, there are 71 landscape genera. ***A landscape species*** is the smallest classification unit identified by using more detailed peculiarities of geological-geomorphological basis (one relief type, one geological formation), climate, soil and vegetation cover (one vegetation formation or a group of associations, soil type). Landscape types are not plotted on the given map.

Outcome 2. A cadastre of the landscapes of not only Georgia, but of the whole Caucasus is developed.

Isachenko points out that our knowledge of natural complexes is insufficient and uneven, and that time has come to unite them in one system and create a single databank **[50].** Geographical data need ordering and classification, which is possible by means of the electronic version of landscape cadastre and GIS. Special significance in applied landscape science is attached to the solution of this problem. Landscape cadastre is necessary, first of all, for the estimation of natural components as well as the whole complex, for organizing their rational and sustainable use, their protection and planning. Landscape cadastre will promote the accumulation and systematization of different branch-geographical data, their coordination to landscapes, for carrying out monitoring and forecasting while making different constructive decisions.

There are certain problems connected with methodological complexity of comparing the data, particularly because of the fact that the data accumulated in branch-geographical literature and also in various institutions has been gathered using different techniques. Therefore, it is often difficult to interconnect the data of several natural components, and for landscape research these interconnections are of great importance. In the given case, the way out of this situation may be carrying out the program procedures, which will provide the overlay of different thematic map layers, the creation of uniform database and the resolution of problems connected with the 'inconsistency' of borders [11].

A great many empirical materials about the Georgian landscapes have given a real precondition to form a landscape cadastre what is very important in many respects. There is bulk of factual materials in a branch and geographical respect, while the information about the landscapes is more or less limited and incomplete. This is why, during the landscape studies; they often use the materials of the branch and geographical disciplines. These materials need to be put as a single system what is quite difficult and labor-consuming by using traditional methods. As for modern technologies, they give a real basis to connect the branch geographical and landscape information with one another. However, there are some problems of methodological difficulties to compare the data. In particular, the information in the branch-geographical literature and at different bodies is gathered by using various methods. This is why it is difficult to interconnect the pieces of information regarding the soil, vegetation covers and other components of the nature. In the landscape study, the study of such connections is very important. The way out may be software procedures of the geoinformation systems, which ensure the combination (overlay) of the layers of different topic maps. They allow creating a single database and solving the problems occurring in case there is incompliance between the borders.

At the given stage, a landscape cadastre is developed (at the level of genera) by using GIS-technologies and e-tables. There are data available for every landscape genus regarding the hydrometeorological data, population number and density, anthropogenic transformation and other indices. Besides, individual thematic maps are developed [19, 51, 52]. The most important part of the cadastre is the inventory of the landscape-geophysical features. It is based on the data of the experimental plots described within the limits of various landscapes.

Outcome 3. Evaluation and models of the landscapes

A great role in modern landscape studies is played not only by the inventory studies and compilation of the maps of the given type (identification, mapping, systematization-classification, description), but also by their evaluation/prognosis in different economic views and territorial planning (development of recommendations).

In Georgia, the studies are accomplished in all those directions. Particularly noteworthy are the works by N. Beruchashvili, which are based on long theoretical and field studies. The "Geographical information heuristic model of the landscapes of the Caucasus" developed by him made it possible to assess the landscapes in the given region on the background of global environmental changes and describe the impact of these changes on the landscapes of the Caucasus, including those of Georgia. The experiments were accomplished based on the model, which can be grouped as follows [19]:

1) Modeling of the dynamics in individual years, including of extreme conditions and calamiteis.

2) Experiments with the changes of climatic properties, though by maintaining the landscape structure.

3) Experiments associated with the change of the landscape structure.

Like the "Geographical information-heuristic model of the landscapes of the Caucasus" by Beruchashvili, the models for individual regions were developed as well. For instance, the data scattered in various branch geographical literary sources and at different institutions have been collected and systematized and a single database was designed for Samtskhe-Javakheti [53]. By using the geoinformation systems, a long data series were processed and thematic mapping was provided. By using a concept of analysis and synthesis of natural-territorial complexes (N. Beruchashvili) and logical chains, a computer model was designed, on whose basis it was possible to identify long dynamics of daily states of the natural-territorial complexes and trends for various landscapes. A landscape map and series of thematic maps were compiled for Samtskhe-Javakheti. A general layout of territorial planning and branch and integral goals of planning were developed. While developing the goals of planning in the course of the project, both, the natural conditions and infrastructure on the one hand and the approach of the local population to various issues on the other hand were considered to the extent possible. The model incorporates the climatic characteristics from the 1960s (1930s in some cases) to present, used as the basis to identify the processes taking place in each landscape of Samtskhe-Javakheti as well as trends of humidification, aridization, air temperature rise or fall.

Outcome 4. Landscape planning

The issues of territorial planning of Georgia are considered in the work by N. Elizbarashvili [22]. The work develops the methodological basis of an environmentally friendly territorial planning of mountain landscapes and gives a large-, average- and small-scale landscape-ecological analysis of the mountainous areas of Georgia with the aim to determine the social-economic functions.

This book is the final output of a study implemented in Armenia, Azerbaijan and Georgia between January 2007 and July 2008 with the support of the German Federal Agency for Nature Conservation (BfN).

The purpose of the study was to pilot the system of landscape planning which has been used widely in Germany for many years as a potential mechanism for supporting spatial planning in the South Caucasus including instruments such as regional plans, municipal plans and environmental assessment of projects.

The studies in landscape planning were conducted in Armenia, Azerbaijan and Georgia in the period of 2007-2008 with the support of the German Federal Agency for Nature Conservation (BfN). The purpose of the study was to pilot the system of landscape planning which has been used widely in Germany for many years as a potential mechanism for supporting spatial planning in the South Caucasus including instruments such as regional plans, municipal plans and environmental assessment of projects [54].

Conclusions

The study has revealed the principal stages and trends of the development of the Georgian landscape school, as well as theoretical and practical results. The scientific works of an applied nature have demonstrated that they are based on fundamental studies, and the landscape maps are widely used for this purpose. Besides, at present, the landscape studies have shifted from the phase of inventory to the phase of evaluation and territorial planning.

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INVESTIGATION OF PRECIPITATION DEPENDENCE ON TEMPERATURE UNDER THE GLOBAL WARMING ON THE TERRITORY OF GEORGIA BASED ON HIGH RESOLUTION 1936-2011 GRID DATA SET

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Abstract

Based on 25km resolution grid climatic data for the 1936-2011 period, obtained at the Institute of Hydrometeorology of Georgia, the effect of air temperature on the precipitation change pattern during global warming was investigated.

The relationship between temperature and precipitation change rates under global warming conditions is mostly negative and is well manifested in all seasons of the year and in general for the year, but in the cold period of the year the positive relationship prevails.

It is established that the temperature and precipitation changes nature in the grid nodes is in close connection with the landscape type. The air temperature decline against the background of increasing or decreasing precipitation is noted mainly in humid landscapes, which is explained by the heat outflow on evaporating or melting. In the non-humid landscapes, however, the air temperature mostly rises and precipitation mainly decreases.

Key words: temperature, precipitation, global warming, landscape change rate

Introduction

It has now been established that under global warming, the precipitation increase is observed in high latitudes, especially in the cold period of the year, and the precipitation decrease - in low latitudes [5, 9, 11, 14, 15]. The section boundary approximately is at 55^0 of northern latitude. Thus, Georgia, located in subtropical latitudes, is to the south of the indicated border, in the zone of precipitation decreasing. However, our studies [2, 3, 6, 7, and others] showed that this thesis is not always justified in the complex physical-geographical conditions of Georgia. A similar picture is observed in other regions of the globe. The dependence of atmospheric precipitation on temperature is determined by many factors, including mainly geographical conditions and the circulation processes of the atmosphere characteristic for these conditions [4, 8, 12, 13].

A detailed study of this problem in Georgia's conditions becomes possible due to 25km high resolution climatic data set developed at the Institute of Hydrometeorology of Georgia, with our participation, for detailed investigation of Georgia's climate change process under global warming [3].

Materials and methods

The source data used were 25km resolution climatic grid data for 1936-2011 periods, obtained at the Institute of Hydrometeorology of Georgia [3].

The obtained data sets actually reflect the picture of the spatial and temporal distribution of temperature and precipitation in Georgia, so they were used as the basis for studying the dependence of precipitation on air temperature during global warming. Statistical and correlation methods tested in climatology have been used.

Discussion

Figure 1 shows grid points for which monthly and annual temperature data sets were created, as well as monthly, seasonal and annual precipitation with 25km resolution for 1936-2011 periods [3].

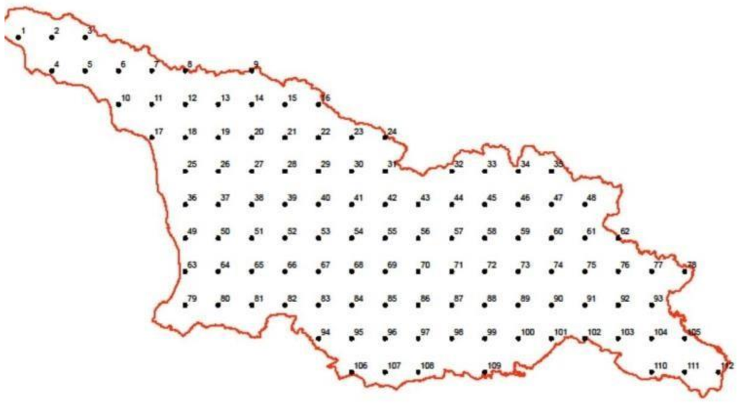


Fig.1. The numbering of points in the nodes of the coordinate grid [3].

These points are located in very complex and diverse physiographic and landscape-climatic conditions, as evidenced by the geographical coordinates of the points, which is clearly seen from Fig. 2.

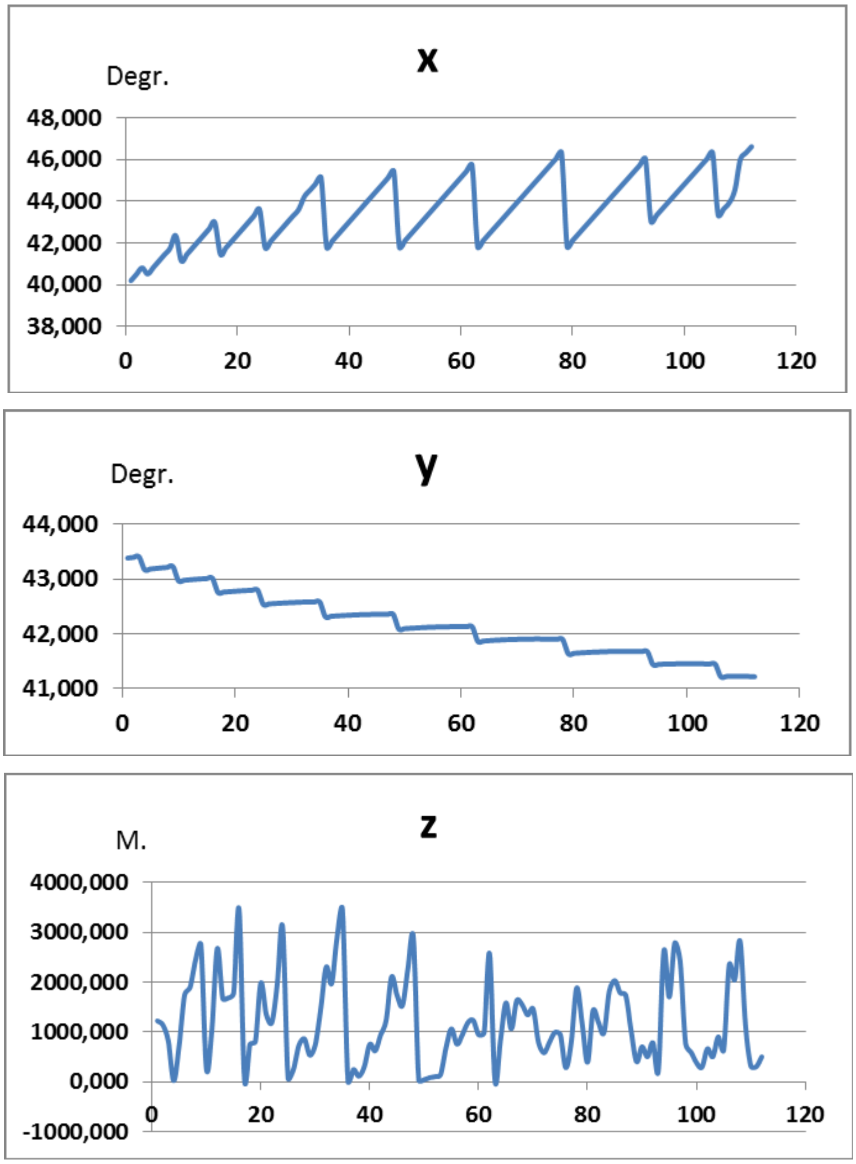


Fig.2. Changing of the geographical coordinates of the grid points: X-longitude; Y-latitude; Z-elevation

Fig. 3 shows the progress of temperature and precipitation change decadal rates at the grid points.

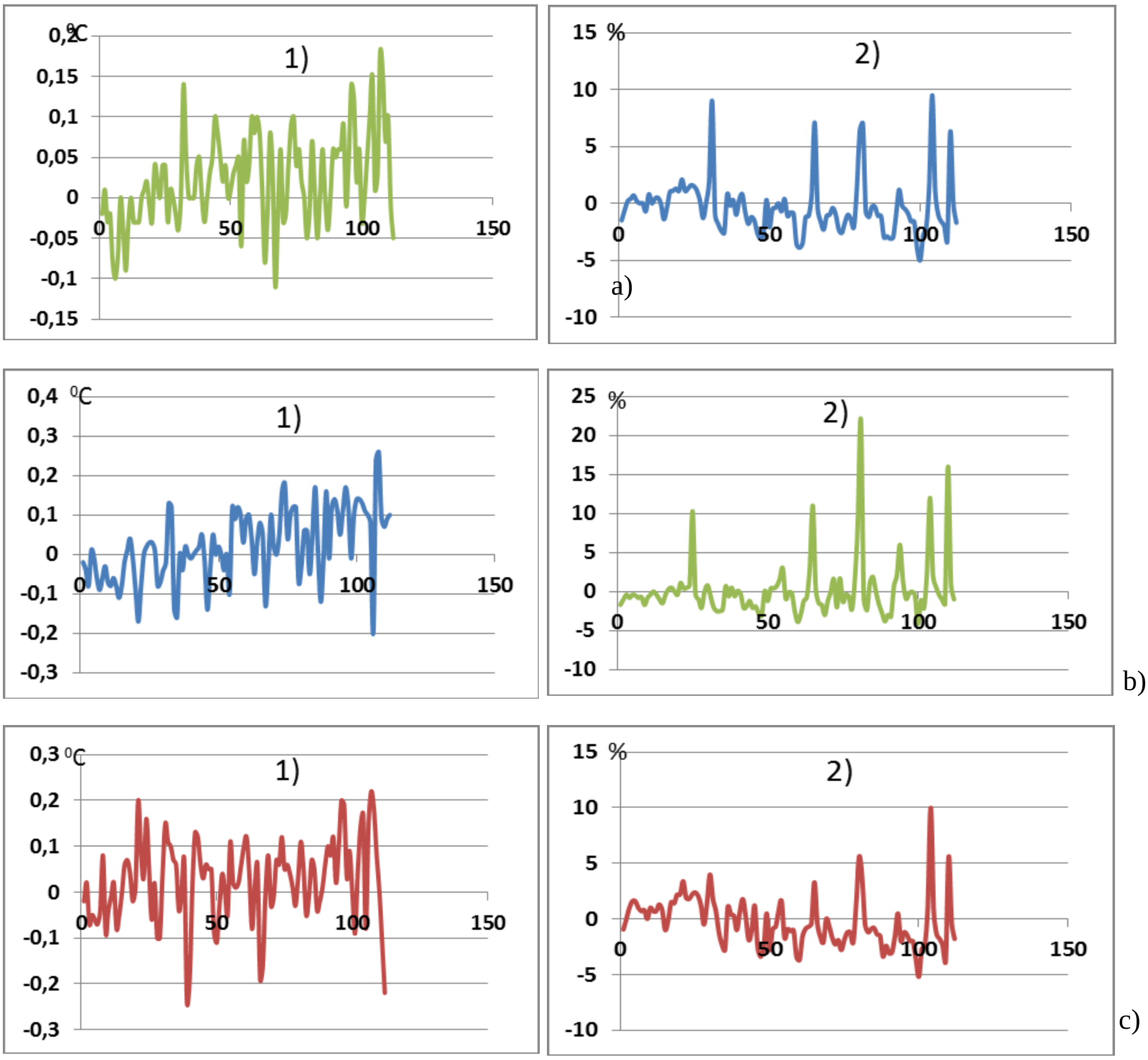


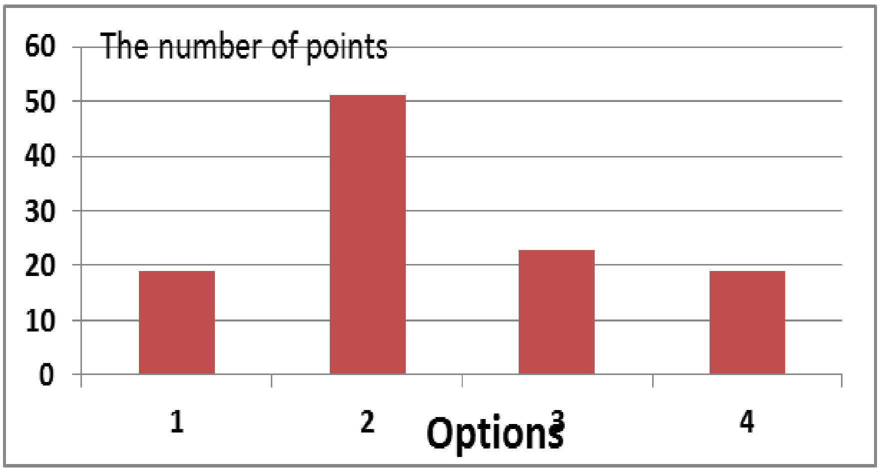
Fig.3. The course of temperature (0C per decade) change rate (1; a-year, b-January, c-July) and precipitation (% per decade), (2; a-year, b-cold period, b-warm period) in points grid for the decade

The fluctuation of temperature and precipitation change rates at the grid points well reflects the diversity of the geographical coordinates of points.

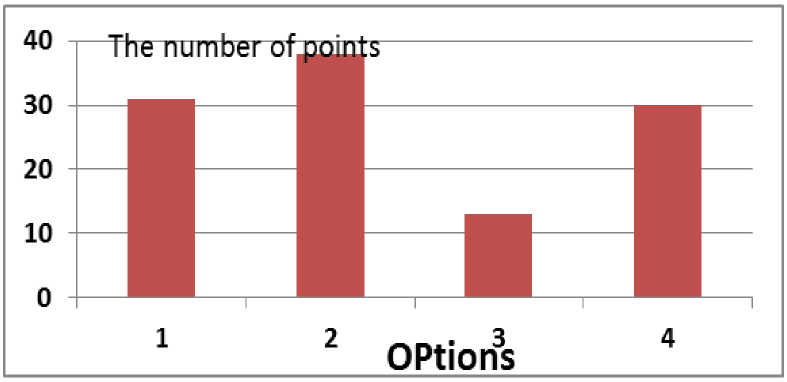
Fig. 4 presents a histogram of various options for changes in temperature and rainfall changes at the grid points.

From figure 4 it follows that the relationship nature between temperature and precipitation is quite complex. Thus, for example, according to the average annual data at most points (in 51 out of 112 points), which is about 46% of the territory of Georgia, the amount of precipitation decreases so there is negative relationship (option 2). At 23 points (20% of the territory), the connection is also negative, however with temperature decrease, precipitation increases (option 3). At 19 points (17%) with increasing temperature, precipitation also increases (option 1), and at 19 points (17%), temperature and precipitation decrease (option 4). This relationship nature is maintained in some seasons, but in the cold period of the year positive relationship prevails (options 1 and 4).

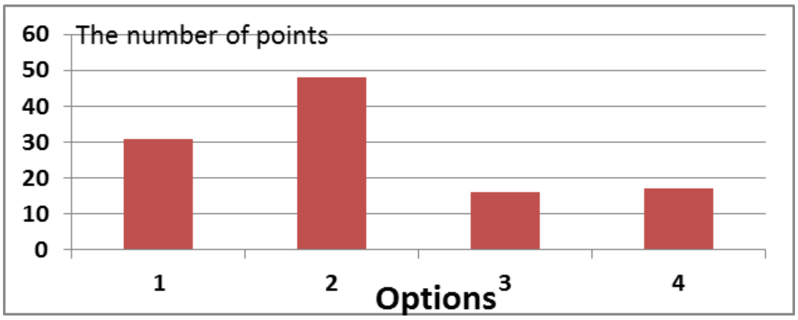
Generally, in Georgia, negative relationship prevails between temperature and precipitation (options 2 and 3). For average annual data, this is noted at 74 grid points, which is about 66% of the territory. In the rest territory of Georgia (about 34%), the dependence of precipitation change on temperature change is positive. During warm period of the year, the negative relationship spreads over a larger area than during the cold period, at which positive relationship prevails.



a)



b)



c)

Fig.4. The number of points with different relationship nature of temperature and precipitation: 1- temperature increases-precipitation increases, 2- temperature increases-precipitation decreases, 3- temperature decreases-precipitation increases, 4- temperature decreases-precipitation decreases.
a) - by average annual values, b) - January temperature and precipitation of the cold period of the year, c) – July temperature and precipitation of the warm period of the year

On Fig. 5. The schematic map of Georgian territory zoning is presented according to the relationship of annual temperature and precipitation sum.

In the result of comparing Fig. 5 with the Caucasus landscape map [1], it can be concluded that the change nature of temperature and precipitation at grid points mainly depends on the landscape type, the elevation is not decisive. For example, in some regions of Western Georgia, significant part of Abkhazeti, Samegrelo, Svaneti, the mountainous regions of the central Caucasus, Adjara and the western part of the

Trialeti Ridge, there are low, negative change rates of annual temperature and increased positive changing rate of annual precipitation, indicating the process of climate humidization (option 3).

In these areas, the elevation varies in 0-3500 m range, but the changing nature of temperature and precipitation is the same. The landscape type is common; here are humid landscapes, in particular, Colchis forest (A), and mountain warm-moderate (H) and cold-moderate (T) landscapes [1].

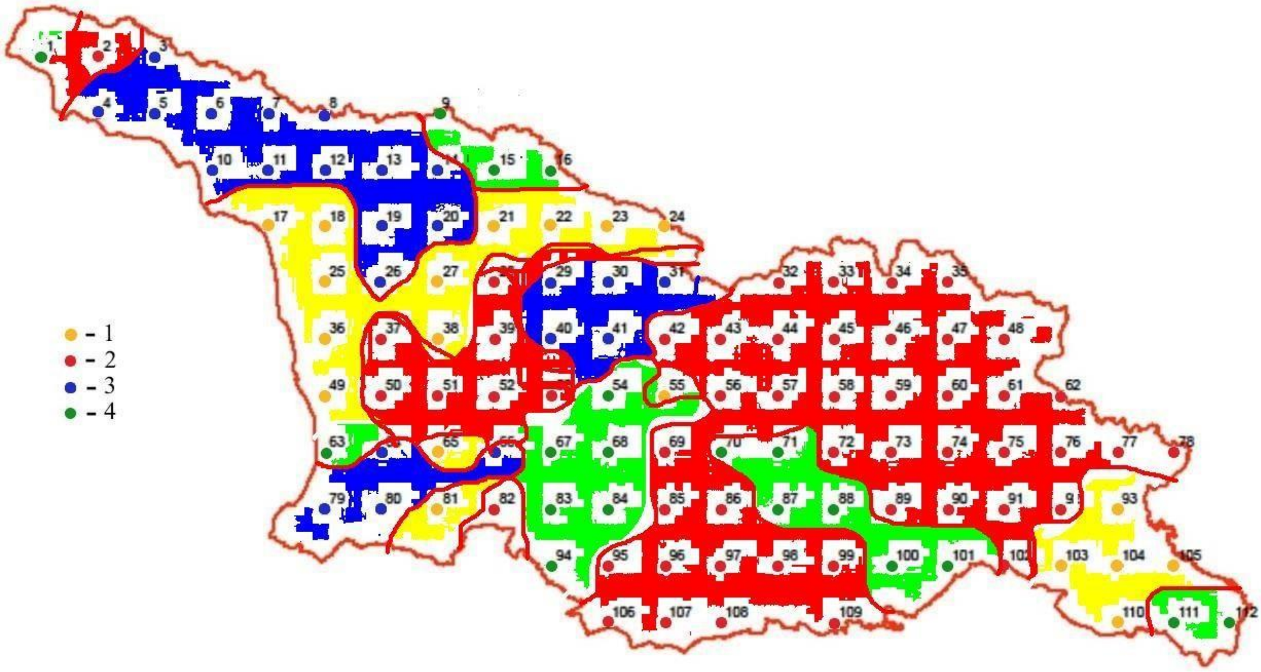


Fig.5. The relationship nature of annual temperature and precipitation sum: 1- temperature increases-precipitation increases, 2- temperature increases-precipitation decreases, 3- temperature decreases-precipitation increases, 4- temperature decreases-precipitation decreases.

On the Black Sea coast and the Colchis Lowland, as well as in the Central part of the Caucasus, in the mountains of Adjara, also on the Eldari Plain, the temperature change rate becomes positive, and precipitation increases too, i.e. the humidization process is also underway (option 1). In the western part of Georgia, Colchis humid forests (A), highland meadow (U) and humid forest landscapes (H) predominate. In the Eldari Plain, in conditions of subtropical semiarid (B) and arid (D) landscapes, significant increase of temperature and statistically insignificant increase of precipitation (10–15 mm per decade) are observed.

On the sizeable part of territory of Georgia, precipitation decreases with temperature increasing (option 2). In the eastern part of Georgia, the temperature decadal rate increases about 0.1^0, and in the western part it ranges within $0.02\text{-}0.06^0$ limits. There are mainly mountain temperate semi-humid (P), moderate semi-arid (P), subtropical semi-arid (L) landscapes. In Western Georgia, where the temperature decadal rate increase is significantly less ($0.02–0.06^0$), there are Colchis humid forest (A) landscapes.

In some areas of the territory, temperature and precipitation decreasing is observed (option 4). This is the territory of Adjara and part of the Trialeti Ridge with Colchis humid forest (A) and humid mountain thermal temperate (N) and cold-temperate (T) landscapes, where annual temperature decreases up to 0.06^0 rate during the decade, and the southernmost minor territory of the Alazani Plain (only 2 points) with sub-Mediterranean semi-humid landscapes (B), where the process of temperature and precipitation decreasing is very weak.

Thus, the temperature and precipitation change nature in the grid nodes is closely related to the landscape type. The air temperature decreasing against the background of increasing or decreasing precipitation is noted mainly on humid landscapes, which is explained by the expenditure of heat by evaporation or melting. In the non-humid landscapes, however, the air temperature rises and precipitation mainly decreases.

Conclusion

The temperature and precipitation change nature in the grid points is closely related to the landscape type. The air temperature decreasing against the background of increasing or decreasing precipitation is noted mainly on humid landscapes, which is explained by the expenditure of heat by evaporation or melting. In the nonhumid landscapes, however, the air temperature rises and precipitation mainly decreases.

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EMERGING ENERGIES, EMERGING LANDSCAPES: EUROPEAN FRAMEWORK

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Abstract

The recent emergence of European Union climate and energy policy has triggered a spectacular growth in renewable energy (RE). Over a decade, decentralized energy infrastructures have spread through rural areas of European countries, transforming their landscapes. This paper provides an insight into process of emergence of renewable energy landscapes in Europe, analysing the impacts of RE on landscapes. The paper provides a round-up of current research into the landscapes being produced by different forms of renewable energy, in particular hydro-, wind and solar energies.

Key words: Landscape, Energy Transition, Renewable Energies, Europe

Introduction

In response to climate change, limited fossil fuels and rising global energy demand the EU climate and energy policy has triggered a spectacular growth in renewable energy (RE) development. Its rapid expansion in European countries is largely due to favourable national policies, based on quantitative targets and economic incentives (feed-in tariffs) as well as more or less favourable social, institutional and political conditions. This energy transition is coupled with an important landscape transition. Spread of decentralized energy infrastructures have through rural areas of European countries, transform their landscapes, raising issues regarding landscape practices and the values associated with landscape protection [1]. While many European countries have adopted and implemented policies in order to initiate a transition to more sustainable energy systems, local opposition based on RE landscape impacts has significantly limited the growth of the renewable sector in some of them [2]. The specific challenge for Europe is to develop renewable energies (REs) while at the same time conserving what we value in landscapes [3].

The values attributed to landscapes in European countries largely depend on national traditions of landscape protection and management, which are also related with the meaning of this concept in each language [1]. Although landscape is approached in a different manner in each European country, the policies for protecting it have been developed since the end of the 19th century along three main lines of thinking [4]:

- The picturesque paradigm, which considers landscape as a part of heritage endowed with a visual dimension. From this perspective landscape has to be protected from visual interferences (co-visibilities) that could alter its visual appearance.
- The environmental paradigm, which considers landscape as a part of the environment, a natural habitat for wildlife and flora. It aims to protect this "natural" landscape through the management of protected areas of different sizes;
- The cultural paradigm, which considers landscape as the result of the interaction between nature and society: landscape is a part of the environment that has been shaped and endowed with shared meaning and values through cultural representations and territorial practices.

This third way of conceiving landscape is reflected in the European Landscape Convention. It defines landscape as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" [5:3]. At the same time, this definition encompasses the picturesque approach that dominated for many centuries [6] and the environmental understanding of landscape. It reaches beyond the expert view of landscape as a purely material entity that has also been in use for several decades. This new way of conceiving landscape has affected the approach to energy landscapes in Europe. At the beginning viewed as de-naturalized and instrumental space, energy landscapes are increasingly perceived as

"Holders" of sensibilities, thoughts and utopias deeply rooted in a territory. Today energy landscape has become a recognized landscape type [1, 9]. Yet further development of the conceptual framework for RE landscape is necessary.

The goal of this paper is to review literature on RE landscapes emerged from different RE systems and to explore negative and positive impacts of these systems on landscapes in Europe.

Materials and methods

The paper is based on a review of the European literature on renewable energy landscapes. The paper provides a round-up of current research into the landscapes being produced by different forms of renewable energy, in particular hydro-, onshore wind and solar energies.

The term 'energy landscape' is used in the sense of a multi-layer landscape characterized by one or more elements of the energy chain (e.g. energy extraction, assimilation, conversion, storage, transport or transmission of energy) comprising combinations of technical and natural sources of energy within a landscape [7].

Results and discussions

A growing number of studies on different kinds of REs [1, 2, 8-10] has highlighted their impacts on landscapes and demonstrated the emergence of a new transdisciplinary field of sustainable energy landscape studies. The impacts of RE systems on landscape were broadly discussed by in [5-8]. While before 2000s researches on hydropower were predominant, nowadays studies on wind and solar energy prevail [11]. The better established among RE landscapes in Europe are hydro energy landscapes, due to their long history of development and to the fact that hydro energy is the most important source of electricity production from renewable resources [12]. Wind energy landscapes extension is also relatively high in Europe, and solar energy landscapes are constantly spreading over Europe due to the boom of solar photovoltaic systems [13]. Infrastructure energy landscape is very present in Europe although further studies are necessary on its different subtypes. It is probably due to the novelty of most RE systems and the extensive nature of direct land occupation that their visual impact on landscape is a widely discussed topic in European countries – especially so for wind turbines [12]. Numerous studies conclude that RE structures may have a significant visual impact on landscapes, especially if they are high, large-scale and/or occupy large territories [2, 10, 12]. The impact also depends on the landscape type concerned, and may be relatively higher in rural areas with open or exposed views (along seashores, on hillsides and hilltops, arable lands etc.). Associated infrastructures may also have a significant impact and often form, a different"infrastructure energy landscape" [10]. Direct land occupation of the facilities raises the issue of competing land uses. RE systems often involve green field development, limiting the opportunities for food production in agriculture or for tourism.

Beyond the direct visual impact of the facilities discussed in many studies [e.g. 2, 9], potentially there are various negative environmental impacts with an influence on landscape character [11, 12]. Changes resulting from the impacts on rocks and soils, water bodies, wildlife and fauna may also affect the perceived character of the landscapes concerned to varied extents. In addition, landscape perception of RE infrastructures could also be affected by other factors, such as unusual smell (in case of bioenergy production) or noise, night lights, shadow flicker and the stroboscopic effect (in case of wind farms).

RE landscapes are dynamic system, shaped both by natural evolution of landscape and constantly changing societal needs and systems of values. In this sense, it is important to take into consideration the evolving character of perceptions of RE landscapes. As any landscape, energy landscape is also shaped by the perceptions of the people who use, share and value them [14], and these perceptions have been evolving throughout of the history of RE development. Several studies showed that whether perception of this landscape will be positive or negative, depends not only on its characteristics, but also on the 'genius loci' shaped by relation between local people and their territory and resources, and reflect multiple layers, systems of values, aspirations and beliefs, associated to these landscapes [12,15,16].

Numerous authors show that there are various solutions available in order to avoid or mitigate negative landscape impacts of REs [8, 9, 10, 11]. Many of the negative landscape impacts of RE systems could be reduced by their proper design, layout and location, avoiding their visibility from particularly sensitive viewpoints, technical monitoring, environmental surveys and specific restoration operations. Location of RE systems in landscapes that have been dominated by extensive technical installations may help to assimilate

RE developments due to thematic association with industrial structures. Placing of power stations and lines as well, as the accompanying infrastructure underground help to reduce their visibility [17]. As for hydro energy infrastructures, utilizing existing old infrastructure like abandoned mills for the construction of small hydropower plants may help to reduce its negative impact on the landscape [18, 19]. Finally, landscape impacts of small hydropower plants may be reduced by establishing reservoirs from natural lakes, or by building large run-of-river plants [20]. Generally small-scale deployments are considered a way to reduce landscape impacts of the most part of RE infrastructures, however have a limited and insufficient outputs to achieve long-term national targets for emission reduction [21] and create cumulative impact of multiple RE plants. Strategic planning and Landscape Character Studies are important tools to mitigate potential adverse landscape and accumulative effects with proper siting, while Landscape Character Assessments provide a good basis for both location and design of RE developments [12].

The main gap in the literature on the landscape impact of RE facilities is that most of the publications focus on the facilities necessary for energy production, while other structures associated with RE systems such as transmission lines, access roads, water reservoirs etc. get less attention. However, they should also be located and designed with respect to the character of surrounding landscapes. An increased research activity in these fields would result in a better understanding and management of this complex issue, and benefit the quality of the landscapes concerned [12].

Although landscape is often cited as an argument in the conflicts that arise around RE projects, its relationship with these developments is not always conflictive [15]. Reviewed literature offer many examples of positive effects of RE on landscape. Generally, the acceptance of these new landscapes is strongly affected by any prior experience of local residents with RE developments [22]. As for their positive landscape impacts we can cite the following:

- From an aesthetic point of view, some RE infrastructures can be perceived as sculptural elements in the landscape, evoke positive association by thematic relation to modern structures, and become associated with technological efficiency, progress, environmental cleanliness and utility [12].
- Some of RE landscapes, like large dams and artificial lakes, can also become tourist attractions [15,19].
- Agricultural and grazing exploitation in wind and solar farms are often generates positive impact in perception of these landscapes.
- Wind mills and photovoltaic modules can also provide shade in spaces where this is needed.
- Finally, both wind and solar farms can be also used for conversion of brownfield (underused, abandoned, and often contaminated land) in productive space.

Utilization of RE landscapes as educational centres and exhibition venues also improve their acceptance by population (e.g. Plataforma Solar of Almeria in Spain). Other practices which improve RE landscape perception are: using wind turbines as observation towers with the aim of utilizing their tourist potential and to improve the awareness and image of RE (e.g., Lichtenegg, Austria; Holtriem, Germany), its integration in nature trail (e.g., Kotka, Finland) or for improving image of environmentally stigmatized areas (e.g., wind turbines on a wast dump hill in Gelsenkirchen, Germany) [21].

This way RE energy infrastructures could participate in the construction of local sense of place and become an important feature of local scenery, as it has been already demonstrated for hydropower landscapes [15].

Conclusions

This paper has summarised the current research into the landscapes being produced by different forms of renewable energy in Europe, in particular hydro-, wind and solar energies. RE structures may have a significant visual impact on landscapes, although their impact depends on height and extension of these installations and the landscape type concerned. In addition, there are various negative environmental impacts and other factors that affect landscape. Generally small-scale RE installations are considered to have less landscape affects then the large one. Negative landscape impacts of RE infrastructures could be reduced by their proper design, layout and location, reducing their visibility.

The relationship of landscape with RE projects is not always conflictive. Generally, the acceptance of these new landscapes is affected by prior experience of local residents with RE developments. In addition, its perception is related with embeddedness of RE infrastructures in the local territory practices.

The relationships of population with renewable energy are not produced by its purely visual perception or aesthetic qualities, but require a multidimensional view of the renewable energy landscape that brings together practices, experiences and perceptions as well as physical properties.

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ANTICIPATED IMPACT OF THE CONSTRUCTION OF ANAKLIA PORT ON THE ADJACENT COASTAL LANDSCAPES

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Abstract

The future development of the marine transport system of Georgia, the necessity of which is undoubted, largely depends on the harboring potential of the Kolkheti seacoast. Among them should be noted the district in front of the Enguri River estuary, which has the most favorable natural conditions for port construction due to the great depths of the Enguri submarine canyon, and it is one of the best in the whole coast for projecting of the future port (Anaklia) here.

Selection of a place for ports in the seashore zone and then designing and building them is a highly responsible task, where a mistake should be excluded. Otherwise, the rebuilding of the already constructed port facilities will be either impossible or too expensive. In this case, irreversible processes are expected that can be expressed in catastrophic changes of seaside landscapes and entire environment. This is particularly about the coasts of accumulation type, where migrations of the beach alluvium during of the sea storms can reach quite large volumes. Therefore, for designing on a high level and proper operating of the future port in Anaklia additional researches and some changes in the port project are needed.

Key words: Submarine canyon, river sediments, sediment transport

Introductin

80% of the coast of the Black Sea coastal zone of Georgia belongs to accumulative type. These shores have been formed during long time as a result of the development of complex litho- and morpho-dynamic processes. Under the modern conditions in the coastal zone, there are in progress also powerful lithodynamic processes, resulting in changes in the shore and underwater slope. Nowadays there is a complex geo-ecologic situation on the sea bank near the estuary of the Fig. 1-2. During a year, their volume for sandy beaches reaches 500-600 thousand m^3 and for the pebbly coasts varies within 30-80 thousand m^3. After the petrographic and mineralogical studies of sediment, alongshore streams [2], [3] divided the Black Sea coast of Georgia into eight lithodynamic systems [3] (Fig. 3). These systems, before rough man-caused interference, were developing continuously, and then were divided into separate autonomous systems and underwent degradation.

Materials and methods

The survey area is located in the central part of the Kolkheti Lowland seacoast. There is a complex interaction between natural and anthropogenic systems. In order to analyze the natural conditions and the Environment Impact Assesment (EIA) in connection with the construction of the Anaklia port, morphodynamic, lithodynamic, statistical, hydrometeorological, cartographic, comparative geographical and also general scientific methods were used.

Results and discussions

The construction of marine ports on the accumulative sea shores requires a highly cautious and accurately calculated approach, as a violation of existing lithodynamic processes there can result in irreversible negative processes. Incorrectly constructed harbor moles and very long entrance channels constructed on the submarine slope are often violating the background natural processes course. For example, the Ochamchire, Kulevi, Poti and Batumi ports and terminals constructed at different times have greatly damaged the existing shores, maintaining the stable morphological state of which is still important today.

Fig. 1. Alongshore sediment transport capacity

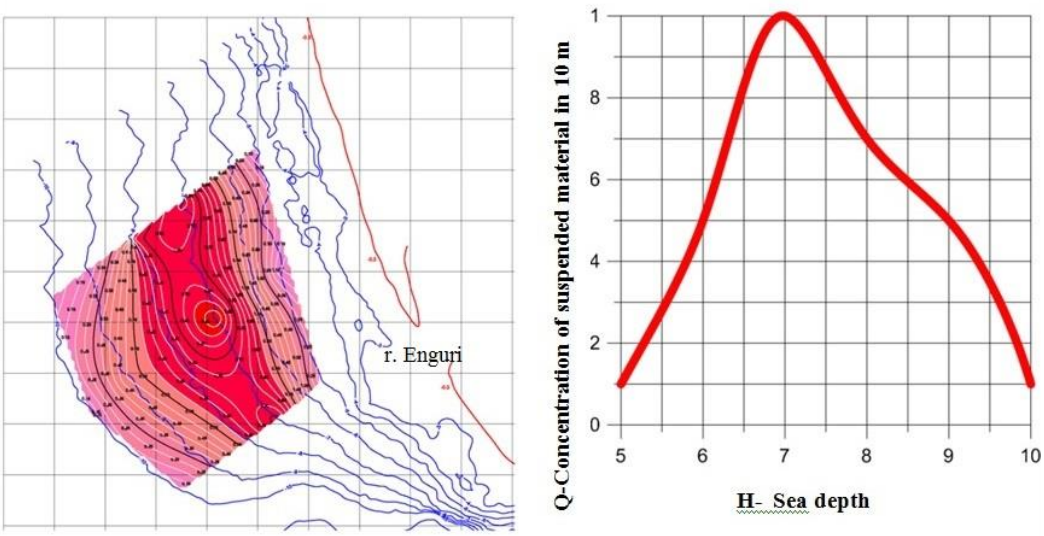

Fig. 2. Concentration of suspended material in 10 m sea water layer near Enguri River seamouth

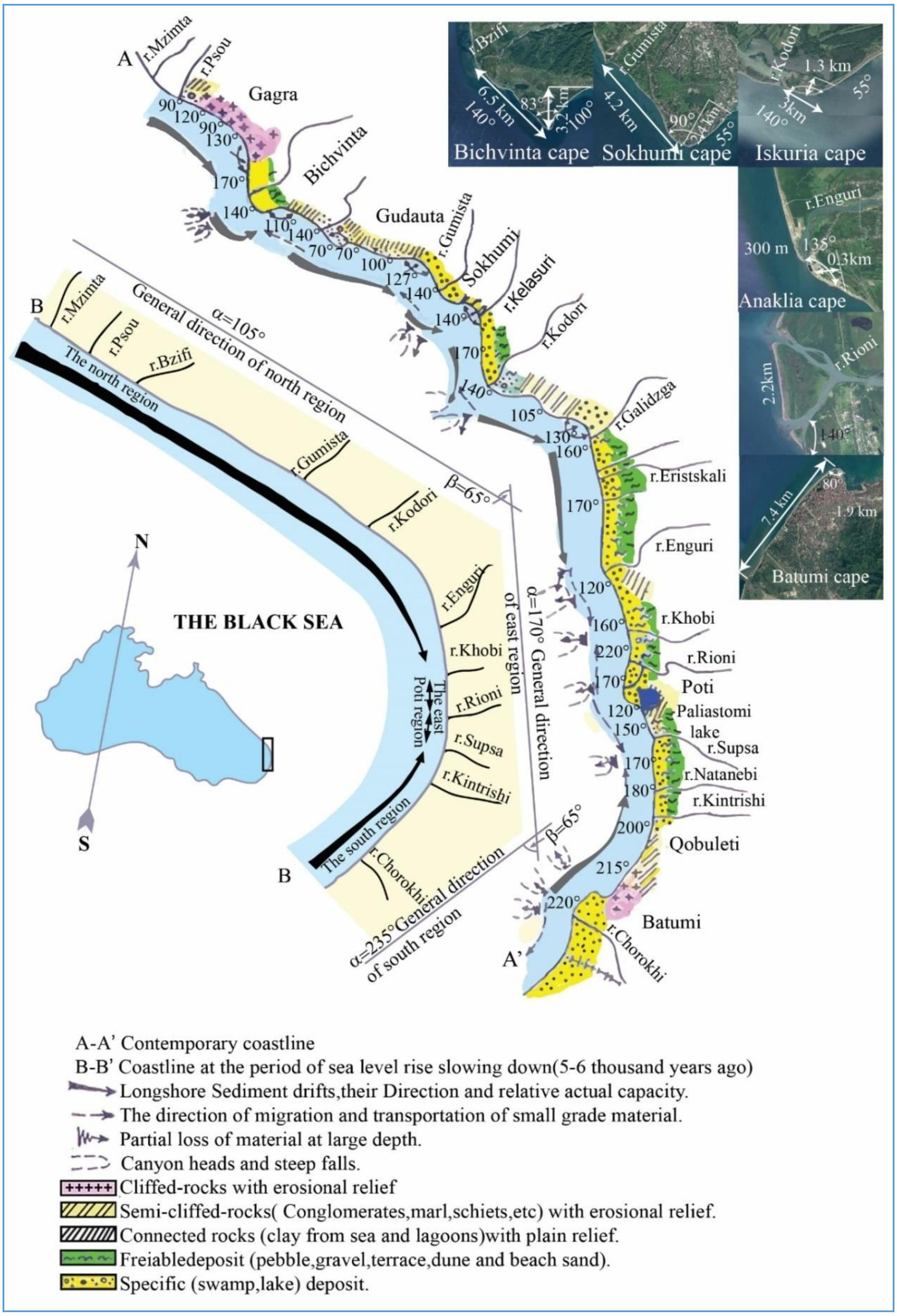

Fig 3. Morphodynamics and lithodynamics scheme of the Black Sea coast of Georgia (By A.Kiknadze)

The part of the estuary of the River Enguri, located near the village Anaklia is the accumulative body, the modern face of which is formed in the second half of the Holocene, before last 4-5 thousand years [4].

The vale relief, adjacent to Anaklia, is distinguished by the low altitudes towards the sea level and wetlands. The vale, located near Anaklia itself, is formed by long lasting accumulation of the Enguri River terrigene materials. From the site of the port construction to the north, in about 1.0-1.5 km, the present day sea estuary of the Enguri River is located, and in the south there are the Churia National Park wetlands. Along the coastal zone, there is uninterrupted 40-80 meters wide beach line. Along this line the old sand-hill (dune) is located, the height of which ranges within 1-2.5 meters above sea level. The mentioned old sand-hill separates the sea and the terrestrial lowland areas, which is one of the conditions for geoecological sustainability of the Kolkheti National Park.

The underwater slope, located along the coast, is characterized by a complex structure. In a shelf line with small inclination is incised a deep-water submarine canyon, whose sources are very close to the shoreline. In particular, the nearest effluent of the underwater canyon in reality starts from 5 meter depths and is 180-200 meters away from the shoreline. Enguri submarine canyon played a significant role from the lithodinamic point of view in development of the coast. An important part of the river sediment was flowing into it, but the remaining sediment was sufficient for the stable development of the shore. After the launch of the Enguri hydroelectric power plant in 1978, the beach-creating sediment deficit started, which resulted in the erosion of the banks. According to cartographic materials at our disposal, in the Anaklia future port's section was observed the maximum width - approximately 100-120 m of the terrestrial strip washout. Until 1978, the coast of Anaklia was developing in stable mode. After the construction of the Enguri water power plant entering the Enguri River beach creating sediment into the sea sharply diminished, causing erosion processes (Fig. 4).

After constructing of the entrance channel for ships of the Kulevi terminal (16 km from the Enguri River estuary in the south), in the north of the Khobi River estuary intensive washouts started. In fact, the River Khobi cannot bring the sediments into the sea any more. Also from the north, the beach-creating sediments, displaced along the shore are completely lost in the entrance channel of the Kulevi marine terminal. After the reduction of the beach size, degradation processes of the ancient coastline sand-hill (dune) began. According to the existing paleogeographical data, the old sand-hill (dune) has not experiencing washouts during the past 4-5 thousand years. In case of coast reconstruction works are not performed, the sand-hill washout process will be continued and supposedly in the coming 3-5 year period the sea will invade Churia wetlands. Development of processes in such direction will drastically change the ecological sustainability of the mentioned section of the Kolkheti National Park. After the construction of the Anaklia port, the above processes will be intensified, as the alongshore sediment flowing from the Enguri River estuary, due to the harbor moles (impeding effect) constructed in Anaklia, will not reach the shores of the sea, located in the north from Khobi River estuary.

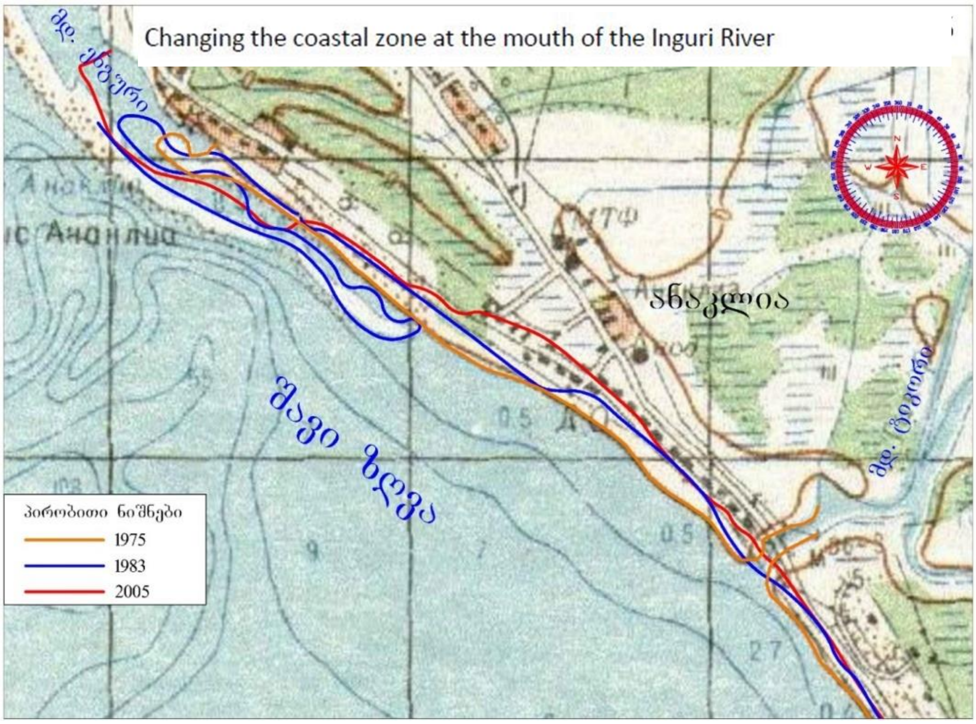

Fig 4. Coastlinee changes near the r.Enguri sea mouth

The mole (breakwater) envisaged by the project will well protect the port's inside water area from the waves coming from the north and west directions, but it stays practically unprotected from the waves, coming from the south-west direction. During the construction of the port, deepening works of the existing bottom surface by means of dredger pumps and excavators are foreseen. In total, 16.2 million m^3 bottom grounds are to be removed including construction of the internal water area, making of the access channel and construction of the mole (breakwater) (Fig.5). It should be noted here that extraction of such a volume of bottom grounds from the accumulating shore will have a negative impact on the coastal zone. Part of the extracted sediment will be used to raise the land of the future harbor. The rest part will be filled in into the submarine canyon. Prior to the start of deepening works, it will be necessary to perform projecting and research works, which should include marine drilling and geolocation.

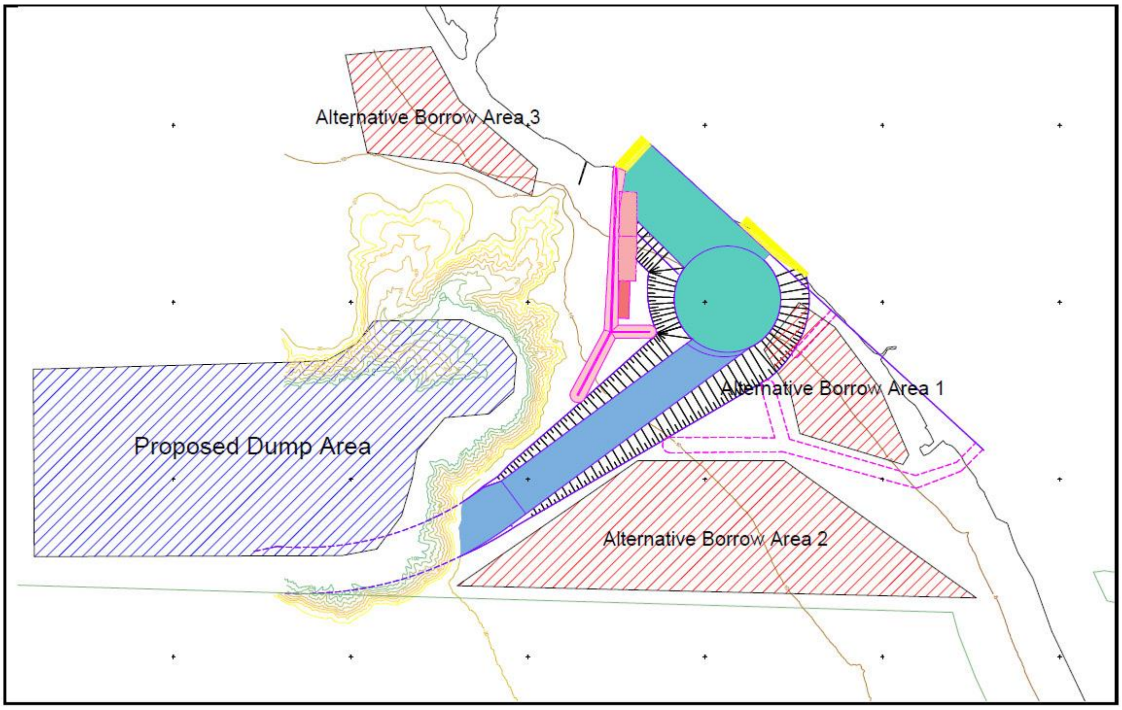

Fig. 5. Anaklia sea port project first stage

During the construction of the northern mole of the port and after construction, the shade of the wave field will be formed for the shores, located on the south. This will result in sediment migration from about 1.5-2 km sector, located under the shade, to the north. In such a case the following is expected:

1. Sanding processes in the turning basin of the harbor where the depths will be gradually decreased significantly;
2. Due to the created deficit of sediment, the washouts will be started in south, on the beaches, located outside the wave shade.

Based upon the submitted schemes of the 1st phase of the construction of the port and access channel, it is possible to say that the inside water area of the port stays unprotected from the quite strong waves of the southwest direction. Considering the great -18 m depths of turning basin, -18m depth of access channel and -18m depth of the port wall, it is possible to imagine how strong shock will have a 2-3 meter tall wave while wall collision.

In the south, outside of the shade of the wave, the shore and the underwater slope washout processes will be aggravated, which will accelerate the degradation of the old sand-hill (dune). It should be noted here that today the construction of coast protective sunk breakwaters is in progress. At this time, two breakwaters are built. Unfortunately, the constructed breakwaters have not yet fulfilled their function.

Conclusions

1. In the EIA report, submitted in connection with Anaklia port construction, the coast baseline description and analysis are not duly estimated;

2. As the impact area of construction and exploitation of the port, taking into account the course of the baseline lithodynamic processes, can be considered the coastal zone stretched from the Enguri River estuary to the Khobi River estuary–in total 16 longitudinal km. It is necessary to review it in the report.
3. The report contains only one alternative for the location of the harbor moles. This alternative does not involve the use of great depths of underwater canyons. Therefore, it is necessary to develop and review a second alternative, where the great depths of underwater canyons will be used during disposing of moles appropriately. In this case, the length of the port entrance channel will be shortened and accordingly will be reduced the amount of sediments to be extracted and work volume as well – by about 5 million cubic meters.
4. During the construction of the north moles of the port and after the construction, the shade of the wave field from the south-west direction will be formed for the south coasts. This will cause sediment migration from the sector of about 1.5-2-km, being under this shade, to the north direction. In this case it is expected:

- Sanding processes in the turnover basin, where the depths will be gradually decreased significantly;
- Due to the created sediment deficit, the washouts will be started in the south, on coasts, located outside the wave shade;
- This process will be implemented until the mole, foreseen by the second phase, is built.

5. Special attention should be paid to the problem of maintenance of the old sand-hill (dune). If the dune undergoes further degradation, the seawaters will likely incise in the Churia National Park wetlands, which will significantly change the ecological conditions there. The water level of existing wetlands is 0.9-1.2 meters above sea level. In consequence of degradation of the sand-hill (dune) and the lowering of the beach in front of it, in the Churia marsh the water level can lower. This process will in turn lead to a noticeable change in the surrounding territories, surface water and hydrogeological conditions.

Recommendations

1. To develop a second alternative of the disposition of the moles that envisages arrangement of the harbor gate from the side of the submarine canyon.
2. To develop the SWOT-Analysis for two alternatives to the harbor arrangement - from arrangement of the gate from the side of the canyon and arrangement of the gateway from the southwest direction by means of making a long access channel.
3. To develop mitigation measures for maintaining of the old sand-hill (dune).

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CONCEPT OF LANDSCAPE SERVICES AND APPLICATION

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Abstract

During the last years the concept of ecosystem services has become very popular. Recently an additional term has been appeared and is increasingly used: landscape services. For its meaningfulness several arguments are ascertained, e.g. spatial aspects, the more contextual view, the greater role of human-influenced areas, its practical applicability, especially the high relevance for landscape planning and practice.

Landscape services are the contributions of landscapes and landscape elements to human well-being. In specific cases we explicitly use the term 'landscape' instead of 'ecosystem' to underline multiple dimensions besides ecological issues.

Key words: biomass potential, landscape planning and management, natural potentials

Introduction

In view of the growing anthropogenic load on the global ecosystem, as expressed in such phenomena as the energy and climate problems or the dangerous loss of biological diversity, it is becoming ever more urgent to control the various and increasing claims upon limited resources, and to ensure sustainable land use [1]. In this regard, the concept of ecosystem services (ES) is currently dominating the debate in the area of sustainable land use management [2,3]. Although humankind has availed itself of the services of ecosystems and the landscapes since time immemorial, and although experts are becoming ever more conscious of the value of natural processes in ecosystems/landscapes we are still a very long way from any general acceptance of these facts, and from the actions to be taken as a consequence.

ES are benefits rendered by nature and used by humankind. According to the Millennium Ecosystem Assessment [4], they include supporting services (e.g. nutrient cycling), provisioning services (e.g. food supply), regulating services (e.g. climate regulation) and cultural services (e.g. opportunities for recreation and tourism). The basis for the concept of ecosystem functions, goods and services is a multilayered approach to the interface between environmental issues and societal claims, with special consideration for economic aspects [5]. However, these are viewed in close connection with ecological and social aspects, with integration across all three pillars of sustainability (SDG goals, [1]).

The complex topic of ES is being addressed by scientists from very different disciplines. Accordingly, approaches and concepts of terminology and methodology are manifold [3]. For example: What is meant by 'natural capital'? What is the 'landscape level'? What is the difference between the 'potential', the 'function' and the 'service' approaches? What are the real 'benefits' of the ecological systems for all forms of human use, and how are they to be assessed, valuated, planned and managed?

The present paper takes up these issues, and focuses from a primary landscape ecological viewpoint on:

- theoretical, terminological and conceptual issues at the interface between the potential, functional and service approaches (based on the pillars: ecosystem properties, potentials and services, the so called 'EPPS-framework', [6])
- the case study 'Cultivation of Energy Crops in Saxony (Germany)' to show the applicability and the advantage of the EPPS-framework for science, policy, planning and management of sustainable land use (e.g. as base of regulatory measures).

Terms and Conceptual Foundations

Natural potentials

Since the mid-1950s at the latest, awareness of human society's dependence on nature has been reflected in the blossoming of theoretical and methodological concepts for ascertaining and describing services, for which purposes adequate terminological systems have therefore become necessary. No longer has it sufficed to speak in general terms about the gifts or the wealth of nature, of ecosystems, or of landscape spaces; now, statements about the efficacy of nature and the landscape have been called for.

The ‘concept of potential’ assesses nature’s gifts from the point of view of the potential user, by means of a primarily scientific mode of operation. It elaborates the service capacities of an ecosystem or physical landscape as a field of options available to society for use, and also to take into account resilience, which limits or may even exclude certain intended uses.

The ‘geographical concept of potential’ was introduced in the German literature by Bobek&Schmithüsen as early as 1949, initially as a “spatial arrangement of naturally provided possibilities for development” [3].

By making natural landscape potentials scientific categories and having them ascertained according to specific parameters of natural processes, they can be distinguished from natural resources, which represent an economic category [7]. Haase [8,9] offered a way out of this hardly manageable complexity by suggesting that, instead of a summary energy standard for a theoretically conceivable overall potential, specific factors (properties, indicators) should be addressed in a particular case, and so-called ‘partial natural landscape potentials’ defined with a clear focus on more specific socio-economic or societal goals and basic functions. These would include for example biotic yield potentials and regulatory potentials, water supply and disposal potentials, and construction and recreational potentials.

Parallel to that, van der Maarel (1978) and Lahaye et al. (1979) in the Netherlands addressed ‘landscape potencies’, which might contribute to the fulfilment of certain societal needs. The term ‘capacity’ of an ecosystem includes the sustainability of a specific function. Thus, the approach of potentials is closely connected with ecosystem resilience and thresholds in ecosystem dynamics, what means the ability of an ecosystem to withstand perturbations without losing any of its functional properties [3].

Landscape Services (LS)

Does it make sense to expand the ES concept to encompass elements of landscape ecology and landscape research, and to establish the concept of ‘landscape services’ (LS), as has been suggested by Termorshuizen&Opdam [10].

The ES term is well established amongst scientists and governments, so that we need not persuade policy-makers to use the LS concept instead. Nonetheless, there are considerable opportunities to use arguments from landscape-related approaches to enrich (not to replace) the ES framework.

The LS concept can more fully address the idea of what whole landscapes might contribute to ecosystem functioning and human well-being in future, even though they may presently be underperforming.

Taking the literature review and the own studies into consideration, we can note that compared to ES, LS show the following special features [11, 12];they:

- arestrongly related to landscapes and landscape elements rather than to ecosystems;
- broaden the perspective beyond the services closely linked to ecosystems, and place more emphasis on aesthetic, ethical and other socio-cultural aspects thanES do (with the exception of socioculturalES);
- express a stronger reference to spatial characteristics, e.g. the configuration of ecosystems and land use units in spatial, structural and process-related interactions (pattern-process relationships), the consideration of neighbouring effects, and the spatial position of service supply and demand;
- are more strongly focused on anthropogenic effects (e.g. land use), as the term ‘‘landscape’’ explicitly includes the interplay between humans and their environment, while ecosystem represents the relationships between a biocoenosis and its habitat or environment;
- support a more integrative view, e.g. the linkage of the social concept of space (space of perception and space of action) with the physical concept of space (e.g. ecosystem complex), and emphasize the total character of an area (landscape peculiarity);
- use landscapes as spatial reference units, which simplify the understanding of the complex interrelationships of characteristic conditions in different areas;
- bring various scientific disciplines together, because aspects of nature, culture and land use are addressed equally, although the individual scientific disciplines use different landscape definitions;
- are more relevant to the practice of landscape planning and landscape management, and encourage communication and participatory approaches (landscape as ‘‘a unifying common ground’’).

A practical application example: Cultivation of energy crops in Saxony

In the light of European and national biomass targets and action plans (e.g. the German biomass action plan, [13]), energy crops can be expected to account for an increasing share of agricultural production in coming years. For example, the Free State of Saxony (Germany) has set the target of increasing the share of biomass in the final energy consumption of power and heat from the present 3.5% to 10% by 2020. In particular, this goal is designed to meet the requirements of environmental and resource protection in accordance with the principles of sustainable development. In the following, it is shown how one can analyze the providing service 'biomass for energy use' (Biomass potential from landscape management):

The potential area for bio-power generation in Germany is approx. 3 to 4 million ha [14]. In addition to this so-called residue biomass, plantation biomass is increasingly important. This includes primarily material from landscape management, the use of which can be compensated with a Landscape Management Bonus under the German Energy Feed-In Law [15]. Regional energy use of biomass from landscape management is to make a long-term contribution to meeting our future energy requirements.

The engineering firm of Bosch & Partner has assessed the potential for biomass from landscape management under contract for the Saxon state Office of the Environment, Agriculture and Geology (LfULG). For this purpose, databases have been prepared for the relevant area types (Fig. 1), such as grasslands, shorelines or roadside green spaces, and the potential were regionalized through a GIS-supported process.

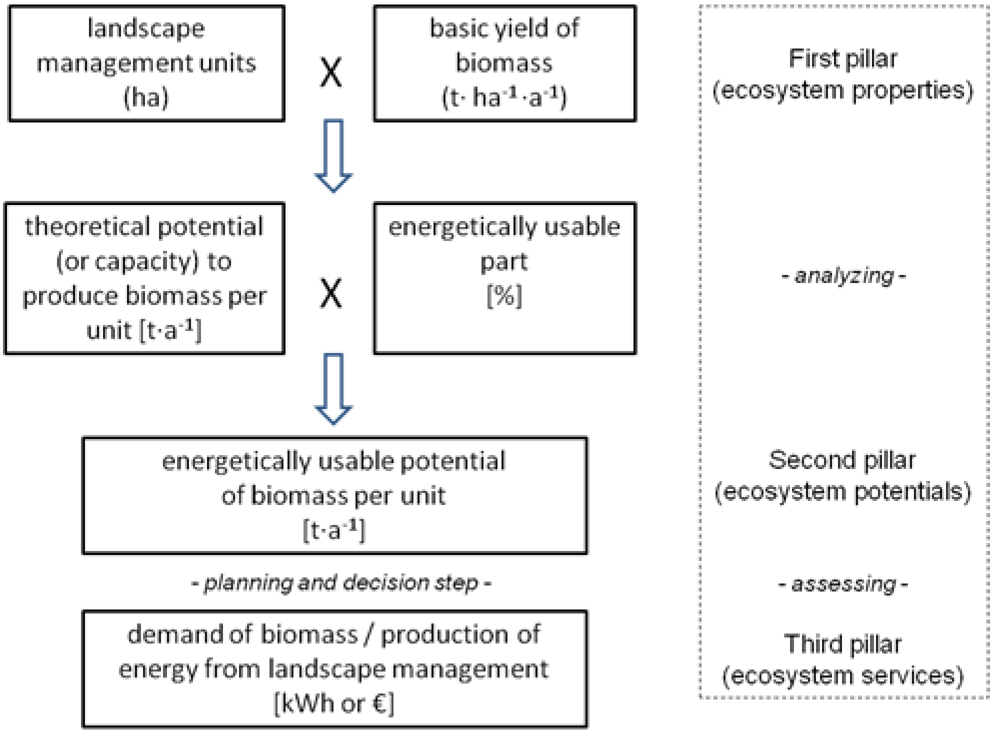

Fig. 1 Algorithm for the ascertainment of the biomass potential [16] and related pillars of the EPPS-framework [6]

The defined landscape management areas which can yield biomass for energy use were derived from maps of biotope types and land use. Less intensively used and semi-natural grassland accounts for the largest share (47%) followed by residential areas with vegetation, with 17% [16].

According to this study, there are biomass potentials (supply) from landscape management in Saxony on approx. 204,000 ha, with a yield of about 667,500 t per year, which would be enough for a viable utilization concept (service demand). These areas can be assumed to yield a biomass potential of stem and herbaceous material in a range between approx. 160,000 and 310,000 t/a, as well as approx. 180,000 t of woody material. At a heating value of 4 MWh/t, this corresponds to approx. 1.5 to 2 million MWh/a.

The utilization of this material for energy purposes could replace between 140,000 and 180,000 t of fuel oil, which corresponds roughly to a CO_2 savings of between 420,000 and 560,000 t.

Result

A geodata-based estimate of the actually available biomass potentials, and an exact identification of the terrain involved – with priority and exclusion areas considering possible risks of biomass utilization has proven to be a feasible way toward avoiding or reducing potential conflicts with nature and landscape management – but it is a path too little trodden to date.

Discussion

Everything nature has to offer for humans – goods, resources, processes, functions etc. – is today frequently seen to be ES, and is so designated. This bears the danger of trivializing and watering down the ES strategy.

Contents and meanings of terms overlap (e.g. ecosystem-landscape or function-service), and different disciplines and scientist have differing perspectives. In view of the large number of papers and the partly quite divergent approaches to ES, the urgent need for unmistakable terminology – i.e. a consistent, logical terminological system – and clear conceptual definitions is evident, e.g.: Are we talking about ecological processes, about potentials, about functions or about services?

The evolution of the concept of ecosystem services has occurred in parallel with the evolution of the multifunctional landscape paradigm [17, 18]. Ecosystem properties build the stock from which ecosystem goods and services are provided, and multifunctional landscapes are the spaces in which this provision often occurs [19]. The differences between the categories 'processes' (in terms of function), 'potentials' and 'services' are in no way trivial. They include both consequences for practical planning and application processes and – especially – theoretical foundations: scientific analysis, planning practice-based foresight, social scientific assessment, and the necessary expertise. The key factor is the degree of anthropogenic perspective, i.e. association with a technical or value-based dimension. For example, the groundwater recharge can be seen as a natural process, independent of human perception or human use interests. If this process is then seen in terms of possible utilization, it constitutes a potential which is transferred by virtue of actually being tapped into a service (demand, market value and use of water).

The reason for the greater incorporation of the potential approach is to present untapped possibilities, and also any over-use and resilience, for with the aid of the potentials, actors have the possibility to choose from amongst several options (such as a comparison of potentials or suitability analysis). This would supply benefits not only to the energy sector, but also it would be of socio-economic significance, and help the reputation of landscape management in society.

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SESSION 1. LANDSCAPE MAPPING, LANDSCAPE ECOLOGY AND BIODIVERSITY

ASSESSMENT OF ANTHROPOGENIC IMPACT ON THE TSKALTUBO (PROMETHEUS) CAVE SYSTEM

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Abstract

Today, in Georgia, more than twenty caves recommended for involvement in tourist routes. However, it should be taken into account that uncontrolled functioning of tourism infrastructure in the cave leads to accelerating the ongoing natural processes in negative terms – the heat released by illumination and visitors transfers to the cave air and speleothems, thus changing the cave climate, which leads to the drying out of cave speleothems, the occurrence of new species of micro and macro-organisms that is often disastrous for the cave. The research object is Tskaltubo ("Prometheus") cave; the goal of the research is to determine the degree of anthropogenic interference in the cave and constant control of the cave micro-climate, the air composition and other data of the cave to maintain the natural climate parameters of the cave. The research identifies, analyzes and ranks the factors that determine the intensity and direction of the mentioned processes. To achieve this, the cave air discharge, temperature, relative and absolute humidity and barometric pressure course were studied both in the cave and on the surface according to daily, weekly, monthly and seasonally. Air movement velocity, direction, radioactivity and gas composition were also studied. The study used thermophysical, thermodynamic and aerodynamic research methods.

Key words: Air, Cave, Humidity, Speleology, Tourism

Introduction:

Georgia is one of the unique regions of the earth according to the distribution of the karsting rocks. Georgia has great prospects for development of speleotourism. The number of karst caves studied in our country exceeded 1300 [1, 2].Unfortunately, the country still can not use these resources properly. Speleotourism is very popular in highly developed countries and brings significant revenue to the state.

The systematic and planned study of Georgia's karst caves began in the Vakhushti Institute of Geography, Academy of Sciences of Georgia by creating the Laboratory of Karstology - Speleology (1958) and by establishment of the Speleo-committee at the Presidium of the Academy of Sciences (1958). With the development of speleotourism, the study of karst caves is of theoretical and practical importance as well. Caves are the kinds of natural laboratories, where one can observe the development of a lot of natural processes yet less researched by the scientists [3]. Absence of highly ionized underground air of ideal quality, allergens and harmful gases has the positive effect on the human body. By foreseen of permanent climatic conditions, the karst caves air has been successfully used for the treatment of bronchial asthma, cardio - vascular system, rheumatism, nephritis, neuralgia, and other diseases without any medical drugs [4]. Georgian karst caves are unique by physical characteristics of subterranean air, such as the climatic (temperature, humidity, pressure, air streams, etc.), aero-ionization (concentration of light ions) and natural radiological (radon disintegration products, and others.) characteristics, proved by the investigations of specialists of the Institute of Geophysics. It should be mentioned that Tskaltubo (Prometheus) cave belongs to the so called "elite" caves in which at the same time many people should not be allowed. It is because of aerodynamics – a little amount of natural traction, which causes a less amount of air in the considerably vast underground halls of the cave.

Tskaltubo limestone massive (area 95 km²) is the integral part of the karst strip in West Georgia and represents a classic example of the low karst development. The massive is divided into the Didvake monoclinal plateau, Samgurali monoclinal mountain ridge and Tskaltubo cave system, which, on their part, are situated on the floor of the above mentioned landforms.

The Tskaltubo – Kumistavi karst region is situated south to the Gormaghali-mountain (1474 m), between the rivers Rioni and Tskhenistskali. Here starts its origin the river Semi (the left tributary to the river Gubistskali) with the research area lying on the left of its submeridian, southwestern bounded gorge. The highest landmark of this place is 768 m, gradually decreasing southwards, by the place Melouri, which is a continuation of the village Kumistavi to its northeast. The height markings of the area do not exceed 500 m. the river Semi bed marking by Melouri, in front of its entrance to the narrow canyon is 382 m. The area is so karstified that on topographic maps in the village Kumistavi, Kvilishori and Melouri environs there are a few streams provided that cannot find their superficial way onwards and get lost underground.

According to the climatic zoning of the territory of Georgia [5, 6] the Tskaltubo limestone massive and its environs belong to the humid subtropical region characterized by mildly cold winter and hot summer. The average annual temperature of the air in winter reaches 6.3^0C and in summer 23^0C. The amount of precipitations fallen during the warm period of the year reaches 850-1000 mm, the maximum of which is observed in October (194 mm). The average annual amount of precipitations makes 1575 mm, out of which 29% of the precipitations fallen over the entire year is during winter time, that of the spring months being the same, whereas in summer it slightly decreases to 25% and then in autumn reaches 32%. Short shower rains are frequent in the massive. The relative humidity of the air here varies within 69-75% throughout the year. The average annual relative humidity makes 73%.

In summer, 1984 the group of speleologists of the Institute of Geography composed of Jumber Jishkariani, Amiran Jamrishvili, Tamaz Kobulashvili, Vakhtang Kapanadze and Kote Nizharadze was credited the honor of discovering all new, yet unknown underground corridors and halls that were partially filled with clay and water, but richly decorated with multicolor/multiform dripstones. The cave represents a subhorizontal, corridor type cavity. The length of the main magistral line, that underwent the development works, is 1060 meters. Power of the limestones under which the underground halls are worked out varies within 8-52 meters. There are two entrances to the cave: one – horizontal, on the floor of a canyon-like gorge, at the height of 147 m above the sea level, and the other, which is relatively more difficult to walk in, is narrow with the much inclined floor on the floor of a swallow hole, opens at 160 m above the sea level.

In May, 2012 the developed and improved karst object was opened for tourists. The cave had 80700 visitors the first year, while the number of its visitors in the second year were 45300. It welcomed more than 200 thousand tourists in a short period of time, among which over 50000 were foreign visitors from different European countries. These figures greatly exceed the average annual index of sightseers visiting up to 800 developed caves throughout the world – 37500 visitors. The exciting years of discovering, exploration and improvement-development of this unique cave system reclined to belong to the history – the new life of the fairyland of the underground world started to breath. After the cave received the first visitors, the systematic hydrometeorological monitoring was stopped, which was carried out by the scientists of the Institute of Geography. It is true that scientific studies are being conducted time to time, but this is not sufficient. The **reconnaissance** works carried out by the scientists in the cave showed the individual signs of proving the above-mentioned influence – the occurrence of mosses and creation of achromatic vegetation cover in the vicinity of the projectors (Fig.1) .


Fig.1. Vegetation cover in the Prometheus cave

The cave's exploitation has already led to unwanted processes and in order the mentioned changes not to become irreversible, it is necessary to conduct urgent research works to minimize the negative anthropogenic impact for cave's sustainable operation.

Materials and methods

The study of speleoclimatic elements/variables is given much attention due to the problems of safe operation of the cave system. A climate research system was developed for the cave, suggesting stationary meteorological observations at different times of the year. The areas were selected for meteorological observations along the main line of the cave, and seasonal stationary observations were carried out on air, water and soil temperatures, absolute and relative humidity, atmospheric pressure, speed and direction of air flow, occurrences of water steam condensation, etc. in non-stop mode. About 2,000 meteorological observations were performed, of which more than 1,500 hours were recorded automatically using self-recording meteorological devices. The researches provided results showing the climatic features of the cave for both the warm and the cold seasons of the year.

The main reason of production of air flow in a cave is the difference between the surface and underground air densities. To calculate the mentioned figures, was used the materials of speleo-climatic observation 24-hour cycle and seasonal observations. It is a widely-known fact that a human being absorbs 1/5 part of the oxygen from the air, while exhaling 17 % of oxygen and 4 % of carbon dioxide at the same time. This means that an average group composed of 20 people will increase the carbon dioxide content in the cave air with 0.3-0.4 mg/l.

During the planned study the thermo-physical, thermo-dynamical and aerodynamical methods of research were widely used.

Aerostatic calculation of natural traction is based on the comparison of the weights of air columns of the same height, which requires calculation of the air density ρ (kg/m^3) both inside the building and in the atmosphere. The value of the ρ significantly depends on barometric pressure P (kpa), temperature (t^{0}C) and water vapor partial pressure P_v (kpa). The air density of the accuracy acceptable for technical report can be calculated using the following formula:

$$\rho = 0.00348\,\frac{P - P_v}{273.2 + t}$$

Determination of the characteristic parameters of thermodynamic condition for external air based on statistical climatological data on temperature and relative humidity stratification and gradients for the different seasons of the year according to the surface relief of the Earth.

At the same time, the thermo-physical calculation of air density inside the cave is associated with the variation of atmospheric air temperature and relative humidity, which in its turn makes it difficult for the thermo-physical characteristcs of the surrounding mountain massif: the relation of the intensity of the process of thermal conductivity and temperature conductivity coefficients.

For the purpose of determining the possible traction and volume of natural ventilation, in the study made an equations for external aerostatic pressure and internal thermo-physical processes. Based on the preliminary calculations, it is noteable that it is possible to eqate the aerostatic pressure with the aerodynamic resistance of the underground passages network, and in the thermao-physical processes the seasonal variation of the air parameters should be taken into account.

Results and discussions

Due to the low natural traction and week aeration except for the entrance area, there is practically no change in the day and night air temperature in the cave of Tskaltubo. The weak air exchange is also proved with the fact that the air temperature in separate individual halls is almost autonomous, comes close to the temperature of the massive of the surrounding layers asymptomatically and does not undergo any seasonal change.

The air temperature of the cave has practically not changed since the works for its development were conducted in it, the air expenditure has increased with 12-15 %, whereas the relative humidity has decreased with the same 12-15 %. The results of the air composition study have proven it that the air does not contain any combustible or toxic airs, such as CH_4, H_2S, SO_2, the oxygen and carbon dioxide content in it is within the norms.

Conclusions

It should be noted that neither the maximum nor the optimal number of tourists, identified in the study, will support to the preservation of natural speleo-climatic parameters, since their calculations were performed depending on the provision of air exchange, which would be sufficient for people's breathing. In reality, when determining the number of the excursionists to be admitted into the cave at the same time maintaining of the speleo-climatic regime should be the benchmark

As one might easily guess, in order to maintain the speleo-climatic regime of the cave, it is required that the natural regime of air flow be maintained according to the seasons of the year, the air temperature increment and the deficit in the relative humidity be liquidated, preserving the natural background of the surrounding massif temperature and humidity content meanwhile.

In order to preserve the stated parameters, we recommend that the air be conditioned using the underground spring water, in the result of which the air temperature will be reduced while the relative humidity will increase at the same time, supporting the maintenance of the indicated natural background of the surrounding massif.

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THE MOST INCREDIBLE REFUGIAL AREAS IN THE CAUCASUS ECOREGION – COLCHIS AND HYRCANIA

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Abstract

Present article is a first attempt to such interdisciplinary investigation. We analyzed patterns of floristic and faunistic richness, endemism, including relict endemics, modern distribution of close relict species in other countries and regions of Northern Hemisphere, specificity of formation of two harbour territories of Tertiary organisms, palaeo-ecological data of the Black Sea coastal and Caspian Sea coastal regions, comparative analyses of the specificity of altitudinal zoning of Colchis and Talysh, at the same time comparing the structure of surviving in mentioned shelters two ancient elements of native flora and fauna – a) tropical-subtropical, b) organisms of the Arcto-Tertiary origination. Finally, critical analyze was dedicated to two refugial centers, which by some botanists are recognized as humid subtropical biocoenosis.

Key words: Biogeography, refugial areas, Colchis, Hyrcania, comparative analysis

Introduction

Caucasus Ecoregion, more precisely Transcaucasia's two refugial centers – Colchis and Talysh (part of Hyrcania) are one of the species-rich shelters for many Tertiary relict plant and animal species which have successfully survived the Pleistocene prolonged periods of severe cold of four times glaciations. Thanks to two refugial regions' extraordinary geographical peculiarity, abiotic factors (mild climate) and natural history of both regions harbouring ancient living organisms are of significant interest for complex way of investigations.

Materials and methods

The biogeographical study and then comparative analysis of two outstanding refugial centers in western (temperate climate) Eurasia – Colchis and Talysh is a result of the long-term comprehensive (floristic, faunistic, biogeographical) studies of the wildlife (in broad sense) of the Caucasus Ecoregion by the author of present paper. The data of complex study encompasses about fifty five years (1962-2018) of field work in all biomes and altitudinal belts (zones) of all (14) natural-historical regions of the Caucasus [1], and all vegetation seasons (early spring – late autumn). The results are presented in twelve books and monographs and many articles in European languages.

Results and discussion

As it is broadly known, refugia are the regions of the Earth, where living organisms endured severe climatic and orographic fluctuations and as a relict forms are still survived. Hence, these shelters of the archaic organisms consist of useful data for solving important problems of biogeography, evolutionary biology, taxons genesis, etc.

The both refugia have some common features, but each of them are distinguished by their own well expressed originality, depending, as we see below, on the geological past of two regions, which have been developed in quite different way.

Colchis (Colchida, Kolkheti) part of western Georgia, is situated between 41° to 45°N and 40° to 46°E. This political and administrative perimeter of the Colchis well corresponds with its natural borders [2]. From the botanical-geographical point of view Colchis belongs to the Eastern Euxinian or Colchian Phytogeographic Province (Subprovince). This region from western Georgia slightly expands to Russia, in the territory of north-western part of the Caucasus (Tuapse-Novorosiysk and to Turkey), within north-eastern part of Anatolia [3]. Therefore, Colchis comprises an area, forming so called the „Colchic Triangle" [2].

The central place of the most humid area is occupied by southern Colchis with western Georgia's two provinces, Achara and Guria. This is a narrow stripe of coastal lowland between the estuaries of the rivers of Tchorokhi and Rioni with considerably humid and warm-temperate climate.

Unlike of Talysh Mountains, a canyon-like mountain gorge of Colchis have preserved high amount of moisture, which support distribution of the Tertiary relict vegetations in high altitude levels, including subalpine belt.

Consequently, the incomparable harbour of the Arcto-Tertiary relict and sometimes relict, and endemic plant species are represented in southern Colchis which except south- western part of Georgia, Achara and Guria, includes adjacent territory of north-eastern Turkey (Lazistan). During the Quaternary glaciation this region was as one of the most reliable harbours for Tertiary flora not only in the Caucasus but in western part of Eurasia in general [4].

Richness of Colchis vegetation as a centre of biological diversity, high ratio of endemism and Tertiary relict species within borders of western Eurasia, is well known [5,6]. Mixed forests of Colchis occupy a considerable part of western Transcaucasia, namely in Colchis lowland and foothills of the Greater Caucasus and the Achara-Imereti Ranges. Its altitudinal distribution ranges from 50m to 500-600 m a.s.l. In upper elevations it is gradually replaced by deciduous forests, more poor with relict species in first stratum of canopy, and higher – it is replaced by coniferous forests [7]. Soils are represented by yellow, brown and red soils with a well developed profile [8]. Forests of complicate, polydominant composition are characteristic not only for rainforest but they also occur in some temperate climate forests due to favourable soil and climatic conditions. The Colchis lowland and foothills aregood confirmation of above stated viewpoint [3]. Grossheim [6] indicated that in polydominant forests of Colchis, major forest-building species include 5 species: chestnut (*Castanea sativa*), oak (*Quercus hartwissiana*), beech (*Fagus orientalis*), hornbeam (*Carpinus betulus*) and alder (*Alnus barbata*).

Ketskhoveli [9] emphasized that in the first half of 20th century an intensive introduction of many subtropical plants in Colchis made a profound reconstruction of primary biocoenosis.

To commonest representative of evergreen undergrowth belongs *Rhododendron ponticum*, which grows as a tall shrub or small tree. It participates in all types of Colchic forests and is spread in mountains higher than communities with canopy forests. The next characteristic species is *Prunus laurocerasus* (=*L. officinalis*), it makes more low stratum than previous species and forms very dense groves. One of the most peculiar arboreal plants of Colchis is endemic box-tree – *Buxus colchica*. Highly valued for timber, it underwent intensive cutting considerably in 19th century [10].

Among the species belonging to relict deciduous trees and shrubs should be mentioned: *Quercus hartwissiana, Zelkova carpinifolia, Pterocarya pterocarpa, Ficus colchica, Rhododendron luteum, Vaccinium arctostaphylos, Coryllus avellana, Frangula alnus*, etc. Is should be noted that in contrast to deciduous component of understory, well developed and lush evergreen shrubs obviously prevailed in discussing region [10]. The botanical-geographical character of Colchic specific evergreen broad-leaved arboreal component of deciduous forest's undergrowth, their florogenetic connections attract attention of many botanists [11 and references therein]. To mentioned communities a special monograph was dedicated by A. Dolukhanov [10]. Phytocoenologically these formations are called "Colchic understory" [10], or "Colchic semi-prostrate evergreen underwood" [12], although in composition of Colchis undergrowth deciduous shrubs participated as well. The exceptional peculiarities of Colchic undergrowth, harbouring Miocene-Pliocene relict living remnants, were largely determined by complex of factors. Physico-geographical factorsshould bementioned: an extraordinary configuration of the Colchis Tringle [2], its location between the Black Sea and the Greater and the Lesser Caucasus Ranges, consequently this region's very mild climatic condition, unusual for moderate climate latitudes of western part of Eurasia (western Palaearctic) [10]. Concerning to biotic factors, competition between the Colchis thick understory and forest-building dominant woody speciesshould be mentioned. The most species-rich relict communities of underforest occur in southern Colchis. This is a region of maximum accumulation of snow cover and considerable amount of summer precipitations [10]. Therefore, the present data and corresponding analysis are based on mentioned key refugium, or as it is named by botanists, "refugium in refugium" [2]. The various formations of creeping (semi-prostrate and prostrate) underforest in the Colchis extend mainly from 1,700 to 2,200m a.s.l. The upper limit of distribution of mentioned thickets coincides with extreme dispersion of crook-stem beech forests, and timberline area in general. In maritime zone's mountains of Achara this upper border is situated even at about 2,250-2,370m a.s.l. The lowest limits of distribution of semi-creeping communities are determined by the types of relief and competition among this kind of phytocoenosis and straight-trunk beech or spruce forests [10]. According to Dolukhanov [10], among all types of vegetation of the Caucasus, semi-prostrate and prostrate communities are most largely enriched with the ancient relict and relict-endemic species. The species of the following generashould bementioned: *Rhododendron, Ruscus, Ilex, Prunus* (*Laurocerasus*), *Epigaea, Daphne, Hedera* and some other deciduous shrubs (*Vaccinium, Rhamnus*). Outside of Colchis, including Hyrcania, these specific formations are in a state of “dying relicts”, whereas in Colchic ecosystems majority of them perform a role of progressive or relicts not reducing their area, consequently being edificatores within underground stratum [6,10].

Golitsin [13] attributes this term to a whole complex of shrubs (22 species), including, besides evergreen shrubs, deciduous arboreal plants as well. Among mentioned complex, the dominant position is occupied by following species: *Betula medwedewii, Rhododendron luteum, Rh. ponticum, Rh. ungernii, Epigaea gaultheroides, Vaccinium arctostaphyllos, Viburnum orientale*. From the viewpoint of Golitsin such formations of shrubs are primary-original plant species that have been formed in the Tertiary Period and remained as relict associationsto present-day.This scholar considers the analogues of mentioned thickets in Madeira and Pyreness Peninsula.

According to Dolukhanov [10], except prevailing evergreen plants, the above mentioned group of communities is distinguished from other bioecological features. Dwarf semi-prostrate trees and shrubs are pressed to the ground under the snow mass and lower parts of their trunks and saber form sprouts that are rooted. In this way plants turn in dormancy. The same rule of semi-creeping growing of the highmountainous plants, thanks to capacity of rooting their trunks and shoots, triggerthe orobiome’s woody plants to vegetative propagation.

Dolukhanov [10] suggests that Colchis refugium is isolated from the other evergreen, semi-prostrate vegetations humid centres, its endemic and other rare species of mountain and highmountain zones that belong to the relict nucleus of vegetation of the remote past.

The most important refugium of South Caucasus is represented by Talysh. Below, we attempted to give appropriate description of some vegetation communities, including the climax communities, which is based on investigations carried out by some scholars and by us (1970- 1975). For the first time a wide spectrum of literature has been used dedicated to investigation of Iranian part of Caspian coastal region (Hyrcania) [4].

The Talysh region is a part of Azerbaijan in the south - eastern part of Transcaucasia. It is located between 38° to 39° N. The territory of the region covers about 4700 sq. km. The local refugium is known as Hyrcania. It is adjacent to the southern and south-western (Iranian part of refugium) coast of the Caspian Sea. It consists of two geographical units, the Lenkoran Lowland and the Talysh Mountains **[**14].

Talysh mountains, directed to the Caspian Sea, turn this site into, “wooded islands” [6].

With respect to Talysh refugium, special attention should be paid to the present climatic conditions. Azerbaijan is situated between mountain systems of the Greater Caucasus and the Lesser Caucasus. Therefore, about 80% of its territory is isolated from the influence ofclimate of neighbouring regions, and only through the Caspian Sea basin this country falls under the influence of arid climate of the Middle Asia. Despite the Caspian Sea (actually lake) area (37.000 sq.km) and volume (78.200 cub.km), this natural basin is unable to satiate with moisture of extremely dry masses, dominating in endless continental, Circum-Caspian arid and extra arid deserts. The only exception is Talysh. According to physico-geographical peculiarities and convenient position of this region and the Elburs mountain slopes toward the sea, Talysh mid-altitudinal zone receives enough quantity of mean annual precipitation, which ranges from 1000 to 1500 mm per year [14,15]. With respect to Talysh region’s annual precipitation total data, it exceeds 1200 mm. The above - mentioned abiotic factors determined the origination and preservation in Talysh and on the northern slopes of the Elburz mountains Tertiary broad-leaved and summer green (nemoral) forests [15,16].

Thus, such individual orographic, physical-geographical and climatic conditions of Talysh region have supported preservation of Hyrcanian hardwood climax vegetation since Mid-Tertiary Period. Finally, considerable role in formation of harbouring center in both sides of Hyrcania (Azerbaijan, Iran), was performed by the following circumstances: this region, unlike Colchis, remained ice-free refugium during all Pleistocene time. All mentioned phenomena provide conditions for their own exclusive peculiarities to formation of flora and vegetations of Talysh, and then transformation of this region into a powerful harbouring center in western Eurasia [5,6].

The main part (95%) of the Hyrcanian refugium is represented in Iran. Despite this situation, Caucasian and former Soviet Union botanists consider Talysh as a part of the Caucasian Floristic Region. The relict forests of Talysh are situated from the Caspian coastal lowland to mid-mountain zone. These communities, in general, occupy an area from 400 to 600m a.s.l., but some representatives through rivers gorges reach about 1,000-1,200 m. a.s.l. According to Grossheim [6], Talysh forests, enriched with relict vegetations, resemble another species-rich Colchis forests, but differ not only in quite different composition of woody species and their biology (e.g, double flowering per year, cauliflory, two periods of growing of woody plants species, etc.), but from phytocoenologic point of view as well. Botanists in unison emphasize absence of dense evergreen understory within local forests. Evergreen shrubs sporadically occur only as an intrazonal formations [14,15,16]. The woody stands of Talysh form two types of forest formations: represented by mixture of some species (polydominant communities), and communities with predominance of one species (monodominant formations). Safarov [16] and Gulisashvili et al. [7] outline several types of Talysh relict forests, Persian ironwood (*Parrotia persica*) forest. *P.persica* is a single representative of *Hamamelidaceae* family in the Caucasus, relict of ancient Arcto-Tertiary flora, as a monotypic genera, survived to present-day.The tree is a native to the forest of southern (Azerbaijan) and south-eastern (Iran) regions, adjacent to the Caspian Sea [16]. *P.persica*is usually found in lowlands, foothills and lower zone of Talysh mountains, stretched out from 400 to 600 m a.s.l., but single trees penetrate to 1,200 m via more or less deep gorges. Today *P.persica* in Talysh does not form an independent forest belt, occurring fragmentally or forming a narrow natural stripe. In lowland ironwood's communities frequently replaced by plantations consist of introduced subtropical cultures. The typical forest with predomination of *P.persica* remained only in lower part of mountain slopes up to 200-250 m altitudes. Above, through the slopes, Persian ironwood appears with admixture of an oak and hornbeam, but from 600-800 m a.s.l. it is excluded from woody stands [7].

These forests are peculiar for the presence of one extravagant feature: as the tree ages, branches are spread horizontally, frequently branches and trunks of one or adjacent trees are fusing, overarching and crisscrossing. Sometimes branches are directed abruptly down, and give around plentiful shoots. Among pure *P.persica* tree stands should be differentiated two main types: ironwood forest with undergrowth composed by evergreen butcher's broom (*Ruscus hyrcanus*) and the same forest with bare-floor [16].

Sometimes *P.persica* coinsides with the native oak - *Quercus castaneifolia* (ironwood - an oak mixture forest) and with an oak, and Caucasian hornbeam (*Carpinus betulus*). The first stratum in such forests is occupied by chestnut leaved oak, hence only the second stratum of canopy is build up by ironwood. Arboreal plant layer are composed by several species of Hyrcanian stock. Native hardwood forests consist of the following species: *Quercus castaneifolia, Parrotia persica, Albizzia julibrissin, Zelkova carpinifolia, Fraxinus coriariifolia, Ficus hyrcana, Diospyros lotus*; in lowland communities participate some other trees: *Ulmus minor* (=*U.carpinifolia*), *Populus hyrcana* and *Alnus barbata* [6, 7, 16,].

Besides mentioned types of woodplant communities, Caucasian botanists outline an other characteristic formations in Talysh relict forests. Among them special interest in wild persimmon (*Diospyros lotus*) forestsarose. It should be underlined that *D. lotus* in Transcaucasia is widely represented in humid regions of the Greater Caucasus, Lesser Caucasus and Talysh, but with well - expressed stratum this woody species is situated only in Hyrcanian relict forests. Today forests with wide presence of *D. lotus*are represented on 10 hectares area, but in the past time, the mentioned forests covered far more vast territories. Today they are reduced due to wild persimmon's value for timber; therefore it is made subject to cutting [7, 16].

"Hyrcanian forest is a natural refugium of western Eurasian deciduous forest region; old-growth, natural, self-regulating forest ecosystems exist up to now. The evolution of the forest ecosystems was not interruptedneither by direct effects of the Glacial epochs nor by severe human influences"[17].

Finally, the evaluation of two harbours in South Caucasus provide ideal targets for investigation of the unique biodiversity of this region's two refugia which are largely (about 900 km) disjuncted today [4].

Conclusion

To compare biotas of two refugial centers of Transcaucasia, it must be stressed mainly an independent formation of two very specific complexes of flora and fauna of two regions. If take into consideration of two harbours different ways of origination within borders of the Caucasus, quite different structure of altimetrical zoning, latitudinal location, specific features of ancient thermo-mesophilous forests between two seacoastal shelters, it should be considered more independent status of two refugia, than phylogenetically close biochores.

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LANDSCAPE-ECOLOGICAL APPROACH FOR ESTABLISHED OF PROTECTED AREAS ON THE EXAMPLE OF REGION ONI, GEORGIA

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Abstract

The important method of preservation of a biological diversity and landscape diversity is a creation of essence of protected areas. Protected areas can be organized by different ways. But there are two basic ways: the state protection, (it is usual at national and local levels) and purchase of the ground by private persons or the ecological organizations. Recently there is an application of a general model where the partnership between the government of a less developed country and the international ecological organizations, or multinational banks and the governments of the advanced countries is established. At such partnership the ecological organizations carry out financing, training, scientific and organizational examination and, helping a developing country to allocate new protected territories. This type of cooperation constantly grows due to improvement of financing on the part of global ecological fund (GEF Global Environment Facility), which has been created by the World Bank and agencies of the United Nations Organization.

In mountainous countries usage of natural resources and their protection should be carried out taking into consideration landscape-ecological aspects and characteristics. This primarily implies identification and study of landscape-ecological carcass of a given territory.

The landscape-ecological approach provides correct planning and sustainable development, of this that is extremely important for Georgia. Main purpose of research, carried out in Oni region is the identification of landscape-ecological carcasses, their study and drawing of maps. Then zones shall be established and elaborated corresponding scientifically, grounded recommendations for established of Protected Areas.

Main results of this component are creation of electronic map of Oni region landscape-ecological carcass and corresponding geographical information system. Based on the above-mentioned system a great number of other thematic maps was drawn.

Key words: Biological diversity, landscape diversity, protected territories, landscape-ecological approach

Introduction

The current state of nature requires the development of new methods of research and mapping of environment. Among them, the concept of a landscape-ecological carcass of a territory is of particular importance, as well as methods related to assessing the sustainability of landscapes and their biological and within landscape diversity. In the early 2000 s. landscape-dynamic studies by prof. N.L. Beruchashvili, began to find practical application in sustainable forest management planning works that started in Georgia with the support of the World Bank. The article discusses these methods on the example of mapping various options for creating protected areas in the Oni region. The developed mapping methodology for the creation of a network of protected areas, based on a comprehensive GIS analysis of the territory, selects such options for the creation of a network of protected areas that take into account both the interests of nature conservation so and the interests of the local population and forest users.

As soon as the territory is protected, it is required to make a decision on scales of human activities to be accommodated there. The International Union of Wildlife Management has developed classification for protected areas which reflects all ranges of intensity of use of territory (IUSN, 2012-2020) [1].

According to this classification the following categories are allocated: Strictly Protected Reserves (I); National Parks (II); National Nature Sanctuaries (III); Controlled Natural Reserves (IV); Protected beautiful landscapes and seascapes (V); Protected territories for controllable use of resources (VI) [2].

The principles of creation of ecological networks are based on three components that functionally complement each other: kernels (nodes, key natural territories), directly ensuring the maintenance of ecological balance, preservation of natural complexes and their components, biological diversity; ecological corridors (transit areas), providing the necessary interconnection between nodes; buffer zones designed to protect the first two ones from dangerous external influences, although perhaps not having independent environmental value; additionally the territories of ecological restoration, where the restoration of natural communities should be carried out.

The parity of protected and unprotected territories strongly varies in different countries. In separate countries protected territories occupy 20-30 % of all territory of a country, and in other they area 1 % less. As it is known, the Caucasus is distinguished by the uniqueness and high level of its bio-diversity. The Caucasus is identified as one of the 25 Earth's biological richest and most endangered terrestrial ecoregion (Mittermaier et all., 1999) [3] – along with the Tropical Andes, Brazil's Atlantic Forest, Madagascar, Mediterranean Basin, Philippines, New Zealand, etc. It is also well-known that Georgia as well as the whole Caucasus is distinguished by the extraordinary biodiversity and here too, the nature protection problems are of great importance.

By Beruchashvili N. L., landscapes diversity of the world countries is shown on the map below in Fig.1. The total number of species is shown on the map below in Fig. 2. The concept and methods of compiling these map are discussed in the articles by N. L. Beruchashvili and J. F. Richard published in Moscow (1990, 1994, 1996) and in Paris (1996) [4, 5, 6].

On the basis of this map (Map Landscape Diversity, Fig. 1.) a calculation was made of the number of landscapes in various countries of the world and on the degree grid in increments of 10 degrees. Of course, this is a rather abstract value, as the degree grid can flow single physiographic regions, disregard the distribution of land and sea, etc. However, it allows you to get the most general idea of landscape diversity based on a grid of coordinates. Analysis of this map allows us to draw interesting conclusions. Unlike biodiversity, when a large country can have a small biodiversity, in a landscape relation; a large country obviously has greater landscape diversity. This is due to the fact that landscape diversity is associated not only with the current hydrothermal conditions and the history of the formation of flora and fauna, but also with geological and geomorphological conditions.

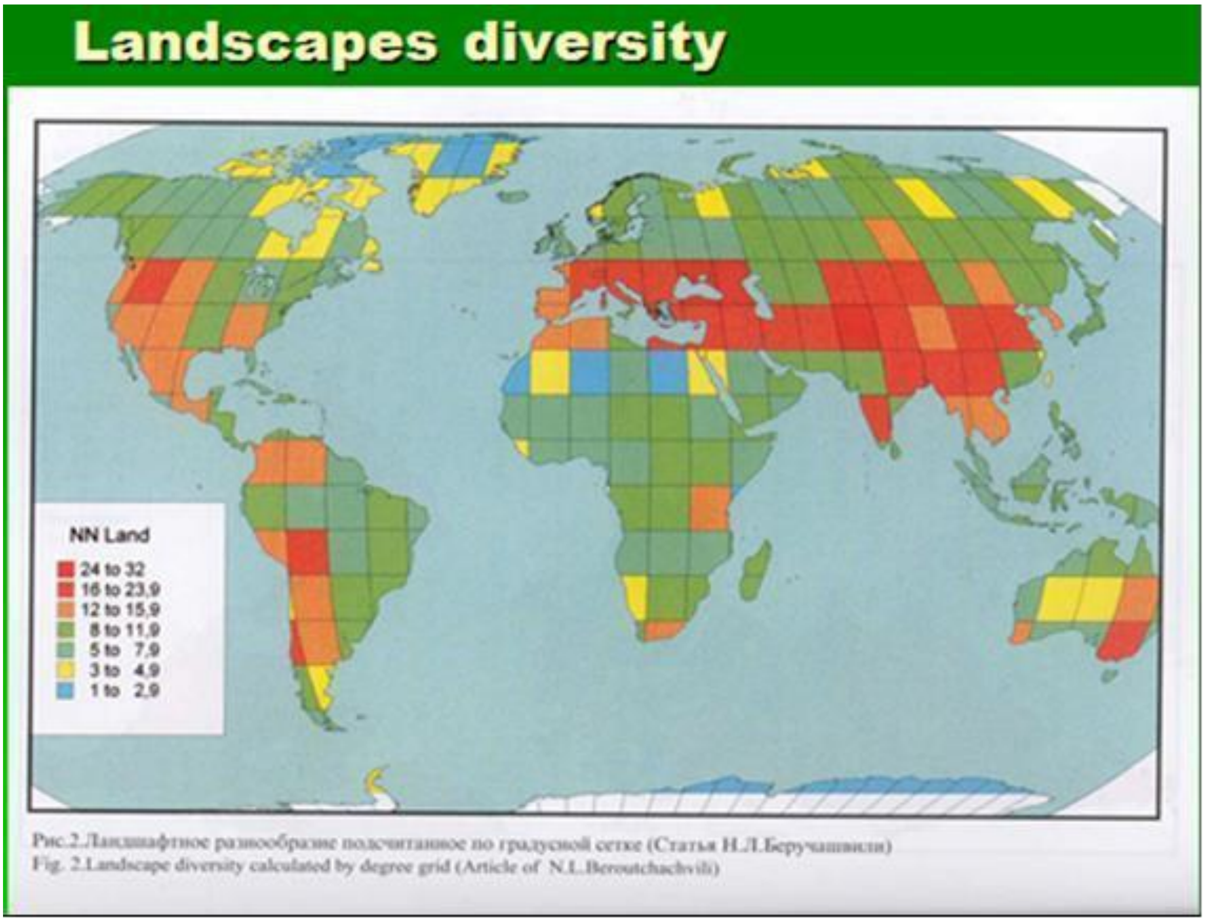


Fig. 1. A map of the landscape diversity of the globe (Beruchashvili N. L. [4, 5, 6])

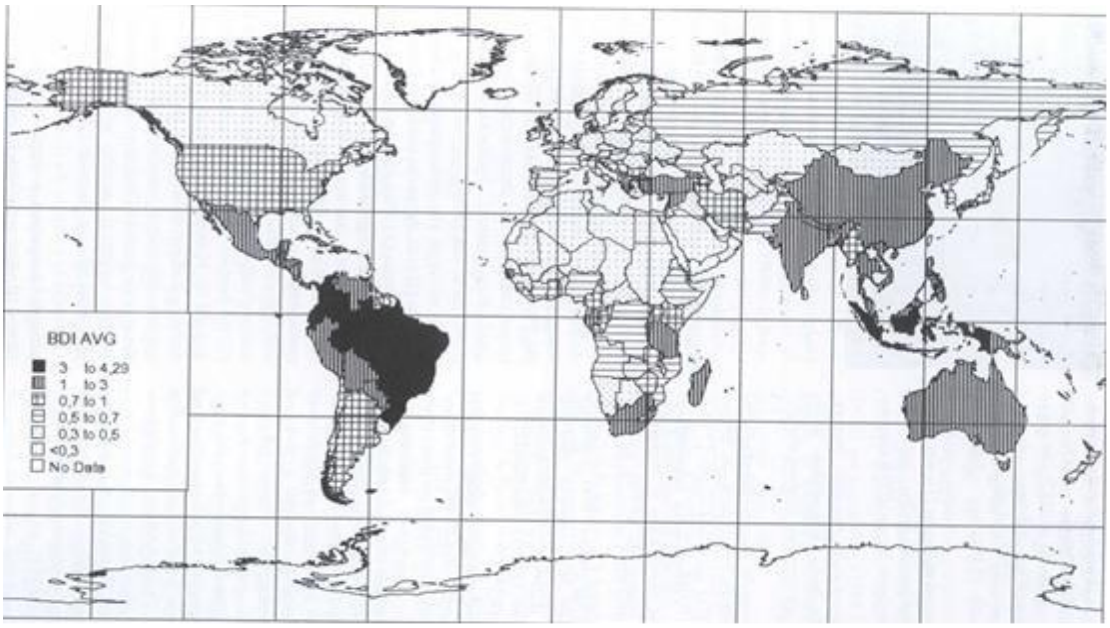


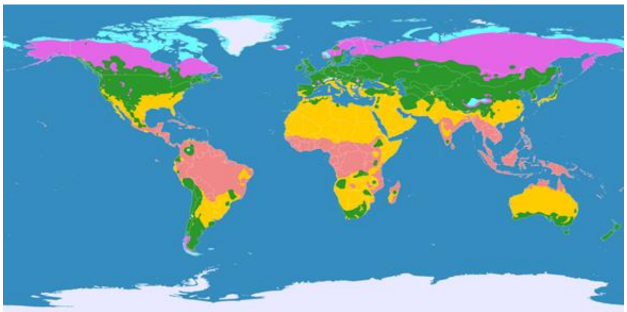
Fig. 2. A map of the actual biodiversity index (by, Beruchashvii N. L.) [8]

The map shows the total number of species is. The quantity of species is counted up by the cells of a coordinate grid. This grid is elongated by 10 degrees latitude and 10 degrees longitude. Apparently from this map the greatest quantity of species decreases at territories with damp tropical woods. High biodiversity is observed in ecosystems of the sub-tropics. The least quantity of species is connected to polar and sub-polar territories, and also with areas of dry an arid climate with desert vegetation.

Map of the actual biodiversity index shows the distribution of global biodiversity within national borders according to the actual biodiversity index. According to BDI index, Georgia occupied middle place. According to this index, Georgia is on the 1st place in Europe, as the European countries, as well as other countries of "moderate breathes" (temperate zone), having a low index. (Beruchashvili N. L [4, 5, 6, 7, 8]).

Fig. 2a. The temperate parts of the world (are green color)

Temperate zone from 40°–60°:
The climate is characterised by less frequent extremes, a more regular distribution of the precipitation over the year and a longer vegetation period - therefore the name "temperate" – "moderate breathes"



In Georgia in the beginning of 1990s the World Wide Fund for Nature (WWF) office of Georgia was established. The Word Bank has been actively involved in these activities, with works on "Georgia's Protected Area Development Project". According the law on "Protected Areas System" on 1996, for the first times in Georgia the categories Protected Areas were adapted to corresponding international categories, mainly to the categories regulated by International Union for Conservation of Nature and Natural Resources (IUSN). As a result, in the last decade of 20th century total territory of Georgians Protected Areas increased from 168800 hectares to 322988 hectares (4.4 % of the country's directory) (N.Zazanashvili, G.Sanadiradze, 2000) [27]. With the financial support of WWF Georgia, a GIS and a map of the Protected Areas of Georgia was created (Fig. 3) , the authors N.L. Beruchashvili, L. Chochua, N. Jamaspashvili, 2000, 2004 [9, 8], which includes all categories of the Protected Areas of Georgia, according to the classification of the IUSN. This map shows the availability in physiographic regions: reserves, reserves and national parks; forests of the green zone, resort forests, subalpine forests and other forests, - which have the status of Protected Areas (forest protected areas) in the Department of Forestry.

Fig. 3. Protected Areas of Georgia [27]

Already by 2012 the total coverage of the Protected Areas of Georgia increased to 520273 hectares (7.46% of the country's Land mass). Trends in the development of the Protected Areas and ecological networks and their management have improved since 2010. New Protected Areas were created: Machakhela National Park (in 2012), Javakheti National Park in 2011 and five Managed Reserves and Protected Areas of Pshav-Khevsureti in 2014. Today total coverage of the Protected Areas of Georgia has increased to 600668 hectares (8.62 % of the country's Land mass) [2] http://apa.gov.ge/en/protected-areas.

Biodiversity can also be judged by ranges of endemic, red book species, unique and valuable plants and animals. Along with this of great scientific interest developed and compiled GIS, Map and Data Bank for selected species from the Reds Books for a unified Caucasus Ecoregion (Beruchashvili L.N., 2004, 2017) [10, 11, 12] (Fig.4, 4a), also and developed and compiled GIS, Map and Data Bank for Virgin landscapes in Georgia (Beruchashvili N.N., 2000, 2007, 2014) [18, 19, 20].

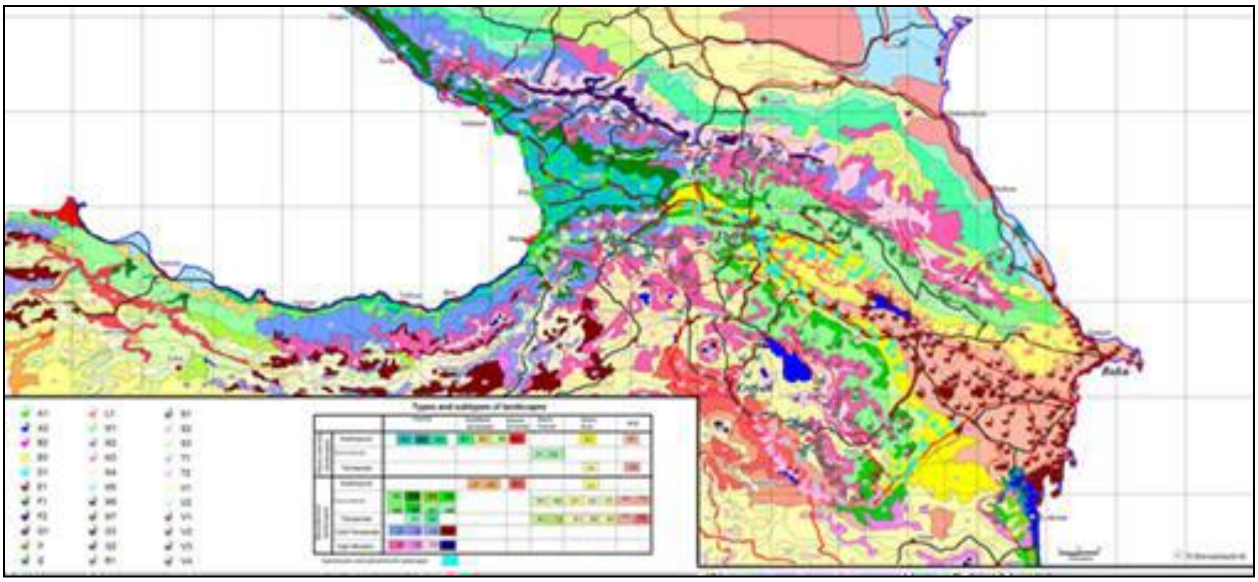


Fig.4. GIS and map of the Caucasus Red Books species (animals), Author Levan Beruchashvili; GIS Landscape map of the Caucasus - Author prof. N. L. Beruchashvili

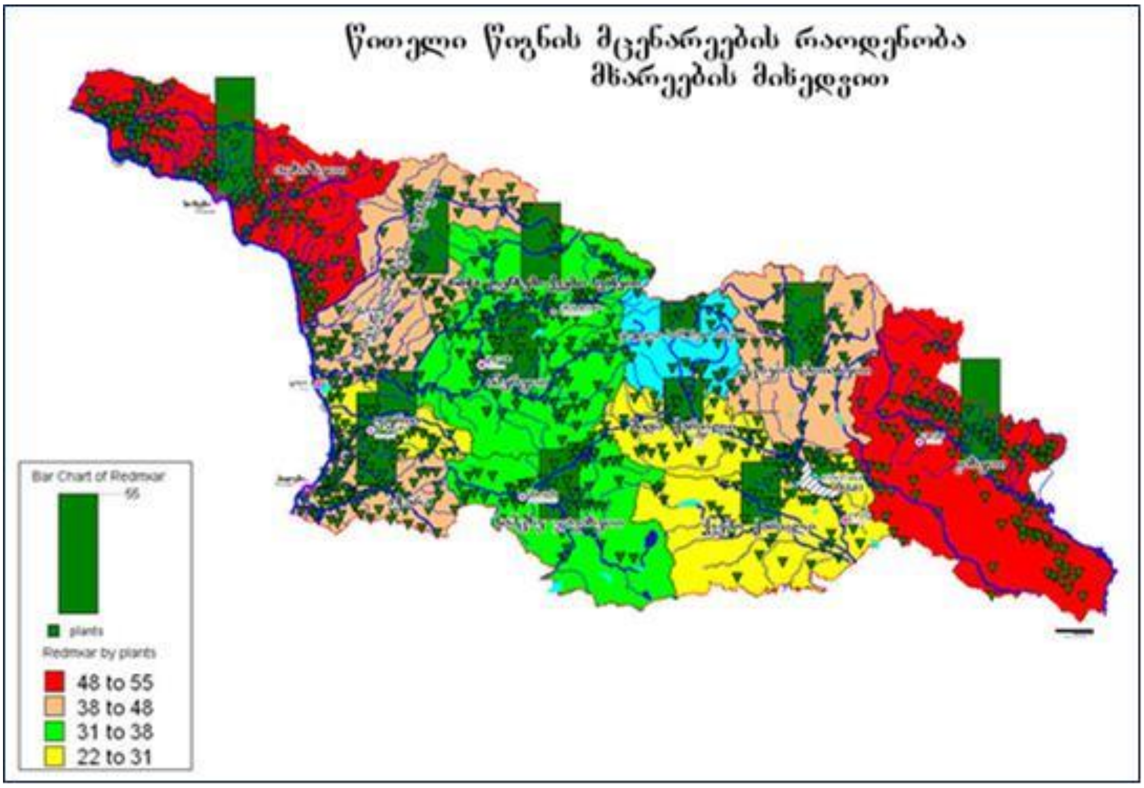


Fig.4a. GIS and map redsbook plants by "mhares" of Georgia, Author Levan Beruchashvili.
("Mhare" – is a territorial unit of Georgia)

As it is known, the Caucasus is distinguished by the uniqueness and high level of its biodiversity. The Caucasus is identified as one of the 25 Earth's biological richest and most endangered terrestrial ecoregion (Mittermaier et al., 1999) – along with the Tropical Ands, Brazil's Atlantic Forest, Madagascar, Mediterranean Basin, Philippines, and New Zea-land etc. [4]. It is also well-known that Georgia as well as the whole Caucasus is distinguished by the extraordinary biodiversity [9] and the nature protection problems are great importance.

In mountainous countries usage of natural resources (including usage of forest resources) and their protection should be carried out taking into consideration landscape-ecological aspects and characteristics. This primarily implies identification and study of landscape-ecological carcass of a given territory.

Materials and methods

A huge contribution to the development of landscape analysis directions introduced prof. N.L. Beruchashvili. He carried out a large number of works in the field of application of space teledetection, the creation of geographic information systems and in landscape modeling.

The study is mainly based on the natural territorial complexes (NTC) space - time to analyze and synthesize concepts (by N. Beruchashvili, 1982, 1983) [13]. The main value of this concept is that it can be based on a common methodology to examine the nature of the components, the natural territorial complexes – specific conditions, the structure and operation of the features, landscapes and anthropogenic transformation of the modern state of quality, develop natural territorial complexes space - time predictive models, etc.

Based on these methods prof. N. Beruchashvili carried out studies in various mountainous regions: Alta, Carpathian Mountains, Khibin, the Alps, etc. [14]. Methodic of landscape research is represented in different scientific research works. They are "Methods for complex physical-geographical investigation: The Manuel" (N. Beruchashvili, V. Zjuchkova, 1997, in Russian) [15]; monography "Geosisteme at Paysages" (G. Rougerie at N. Beroutchashvili, 1991, in French) [17]. Methods of landscape geophysical research and mapping states of natural territorial complexes (1983) [16], in Georgian language this methodic is described in textbook "Landscape Experience of Martkopi Physical Geographical Station" (1994).

We based our research on different cartography sources. Among them were: The Caucasus Landscape Map, 1979 [21] from which we used landscape classification units. Methodic and landscape classification are described in special edition - N. Beruchashvili, Notes on the Caucasus Landscape Map, 1980 [22]; The Caucasus: Landscapes, Models and Experiments, 1995 [23].

In collaboration and financial support with the CEPF and WWF, in the framework of a small grant, a whole range of GIS of Caucasus was compiled.

The Critical Ecosystem Partnership Fund (CEPF) is designed to safeguard the world's threatened biodiversity hotspots in developing countries. One of the most biologically rich regions on Earth, the Caucasus is among the planet’s 25 most diverse and endangered hotspots. The Caucasus is one of the WWF’s Global 200 Ecoregions, identified as globally outstanding for biodiversity. The Caucasus hotspot, with its unique assemblages of plant and animal communities and rare and endemic species, is globally important for conservation of representative areas of the Earth’s biodiversity. Based on the concentration of such species in the Caucasus, critical areas were identified, which should fall into the network of Protected Areas. Forests are the most important biome for biodiversity conservation in the Caucasus. Mountain forests make up the majority of the forest biome in the Ecoregion.

Within this project Beruchashvili N.L. compiled Map and GIS - “Natural Landscapes of the Caucasus Ecoregion” scale 1:500000 (2001, 2003, 2006); [24, 25, 26, 27]; Map /GIS Land Use/Cover of the Caucasus (sc. 1:500000), 2001, 2003, 2006 [24, 25, 26, 27]. (Fig. 5, 5a, 6)

Fig. 5. Natural landscapes of the Caucasus ecoregion, scale: 1:500000. [24, 25, 26, 27]

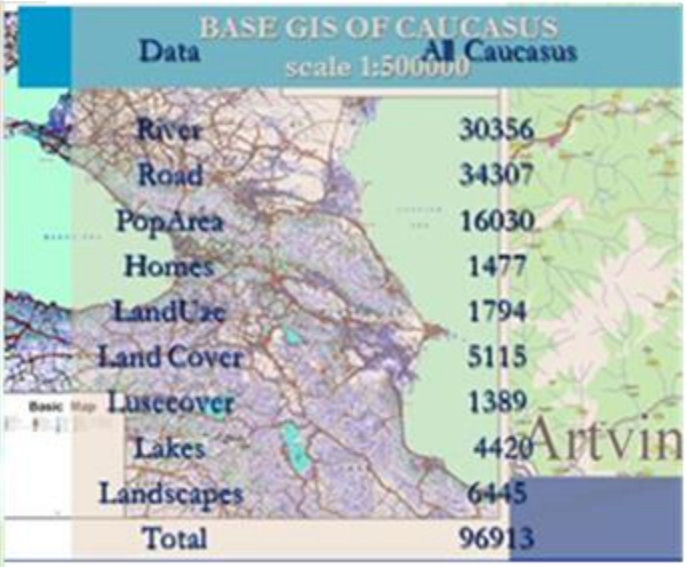


Fig. 6. Base GIS of the Caucasus (scale: 1:500000) (by Prof. Dr. N. Beruchashvili)

Fig. 5a. Prof. Beruchashvili N.L.

The current state of nature requires the development of new methods of research and mapping of the environment. Among them, the concept of a landscape-ecological carcass of a territory is of particular importance, as well as methods related to assessing the sustainability of landscapes and their biological diversity. According to special method, prof. N. Beruchashvili, during the ecosystems profiling process have been development new's GIS for identified of a critical areas in the Caucasus - Conservation of Focal Species and Their Habitats in the Caucasus Ecoregion. Twenty-six focal species requiring urgent measures for conservation were identified for the Caucasus Ecoregion in Priority Conservation Areas, total: 1-56. Because focal species rely on forest, freshwater, marine, and high mountain habitats for survival, the plan includes actions referenced in the respective biome conservation plans. Priority Conservation Corridors, total: 1-60.

Tab. 1.

One of priority Conservation Areas: 11. WEST GREATER CAUCASUS

Location:	Western foothills of the Greater Caucasus Range on the Black Sea Coast
Longitude:	40°00’10’’ Latitude: 40° 43’01’’
Area:	874,535 ha
Econet:	Greater Caucasus
Countries:	Georgia, Russia
Main Biomes:	Forest, high mountain
Main Habitats [1]:	Forest – 593,459 ha (67.86%) including: 102,972 ha of Colchic lowland swamp alder forests and sphagnum bogs, 192,508 ha of Colchic middle-mountain beech forests mainly with evergreen understory, and 221,650 ha of dark coniferous (spruce-fir) forests; total high mountain habitats – 165,622 ha (18.93%)4
Land Use/Land Cover [2]:	Urban areas and rural settlements – 13,878 ha (1.59%); farmlands – 69,882 ha (7.99%); actual forest cover – 672,887 ha (76.94%); summer pastures – 89,237 ha (10.20%); barren and rocky areas – 26,977 ha (3.08%); mires – 321 ha (0.04%); lakes – 425 ha (0.05%); rivers – 923 ha (0.11%)
Protected Areas:	10 PAs totaling 649,671 ha (74.29%): Ritsa Strict Nature Reserve – 16,289 ha

	and Pitsunda-Myussera Strict Nature Reserve – 3,761 ha (Georgia), Kavkazsky Strict Nature Reserve – 278,959 ha (IUCN I – 299,009 ha – 34.19%) and Sochinsky National Park – 193,737 ha (22.15%) (Russia) (IUCN I+II – 492,746 ha – 56.34%); other PAs: Sochinsky Zakaznik (Sanctuary) – 48,450 ha (5.54%), Tuapsinsky Zakaznik – 15,000 ha (1.72%), Dakhovsky Zakaznik – 23,000 ha (2.63%), Psebaisky Zakaznik – 37,400 ha (4.28%), Damkhurtssky Zakaznik – 30,000 ha (3.43%), Zakaznik Bolshoy Tkhach – 3,075 ha (0.35%) (Russia); other PAs – 156,925 ha (17.95%)
Key Phenomena:	Part of the Colchic refugium of humid Pliocene flora; high proportion of endemic plants, invertebrates, amphibians and reptiles, mammals, important populations of focal species
Focal Species:	*Ursus arctos, Capra caucasica, Rupicapra rupicapra, Cervus elaphus, Bison bonasus, Tetrao mlokosiewiczi*
Species of Special Concern:	*Rhinolophus ferrumequinum, R. mehelyi, R. hipposideros, Myotis emarginatus, M. bechsteini, Miniopterus schreibersii, Barbastella barbastellus, Lutra lutra, Mustela lutreola, Lynx lynx, Tetraogallus caucasicus*
Population Density:	Low (except along coast)
Resource Dependence:	High
Threats:	Illegal logging, illegal hunting, overgrazing
CEPF Site Outcomes [3]:	Bichvinta-Miusera NR (21), Ritsa NR (22), Kavkazsky Biosphere Reserve (37), Sochinsky NP (38), Sochinsky Sanctuary (43), Damkhurtssky Sanctuary (51)

In the early 2000 s. landscape-dynamic studies by prof. N.L. Beruchashvili, began to find practical application in sustainable forest management planning works that started in Georgia with the support of the World Bank. Whole ranges of GIS Caucasus were compiled: Diversity of Georgia's landscapes and geographical analysis of landscape diversity of the World [5, 6, 7, 8]; Forestry management work and Green Card, 2002 [29]; GIS and Landscape Map of Georgia [9]. Other cartographic source is data of fieldwork. Inventory of 50 experimental plots was carried out. Apart from that was used data of 1983, 1988, 2000 region and 2010 - 2012 expeditions to Oni region [31, 32]. Other source is map the landscape carcass of Oni region (Figur 7) [29]. Also sources were airspace photos.

Research region of Oni is situated in the Northeast part of Georgia. Area of the region is 1359 km^2.

To the West of Oni region is situated Ambrolauri region. Saphichkia and Kupri Range divide these two regions. To Northwest of Oni region is situated Lenthekhi region. Lechkhumi Range divides these two regions. To the North Oni region is divided form Republics of Russian Federation (Kabardo-Balkaria and North Osethia) by the Central Caucasus Range. To the south and Southeast to Oni region are adjoining Sachkere and Java regions. In accordance with resolution of the Parliament of Georgia northwest part of Java region was transferred to Oni region. From the administrative point, Oni region belongs to Racha-Lechkhumi Kvemo Svaneti district. Administrative center of the region is Oni. From the point of hypsometric spread, nature of Oni region is extremely diverse. This region is located in the central part of the Main Caucasus Range. The region is spread from 600m. to 4461m. (to M. Chanchakhi).

Results and discussions

The database contains description form of 144 experimental sites. Data was obtained at different points of Oni region during fieldwork activities. These data was linked to corresponding types of landscapes and we calculated average statistical indicators for them.

During expedition was surveyed almost whole area of Oni region. Great attention was paid to selection of territories for establishment of future protected areas. It was not an easy task, as by the middle of XXI century must be established not separate protected areas, but a whole network. The network shall consist of protected areas of different categories (reserves, National parks, monuments of culture, biosphere reserve, sanctuary, protected landscape, territories of diverse utilization, area of world heritage and etc.), also buffer zones and ecological corridors. At the same time Oni region network of protected areas shall be a part of Georgia and the Central Caucasus network of protected areas.

Main result of conducted research is elaboration and creation geoinformation system landscape ecological carcass, 1999-2006, 2007-2012 [9, 28, 31, 32, and 34]. The carcass represents a network of landscapes, on which are reflected basic geodynamic and ecological indicators, geographical barriers and ecotones - that is, those areas where there is a gradual change of natural conditions. As a result, the territory is structured into certain cells. They are the level of geosystems that we call landscapes. Based on the carcass we defined sustainability of landscapes and drew corresponding map. The map contains indication of territories of active geodynamic processes and landscapes of high biodiversity, which require special usage regime; also disbalanced territories, which are in need of restoration.

Geoinformation system allows us to promptly and accurately define all parameters, which are connected with landscape ecological carcass of the region. To the above carcass we can link maps and airspace photos. This shall promote accuracy of definition of valuation areas, improve planning measures and promote sustained development. Apart from that Geoinformational system shall allow accurate definition and measurement of areas, occupied by different sites, calculate total, average and other statistical parameters.

Main scientific results of are the following: main geographic barriers and ecotones of Oni region were identified; a computer map was drawn and was carried out analysis of geoinformational system - we came to conclusion, that most relevant are lithological (karst layers, quaternary and young volcanic layers) and climatic barriers (Oni region is characterized by relatively uniform distribution of precipitation: 1000-1400 mm, though minor differences in precipitation determine changes of relief); areas of main geodynamic processes were studied - we concluded, that landslides are mainly characteristic to low mountain plain landscapes, though sometimes they are characteristic to average mountain landscapes as well; mudslides and mudslide hazard territories are quite widespread and are connected with lithological barriers (rockslide is characteristic to average mountain landscapes, but mainly is connected with high mountain landscapes).

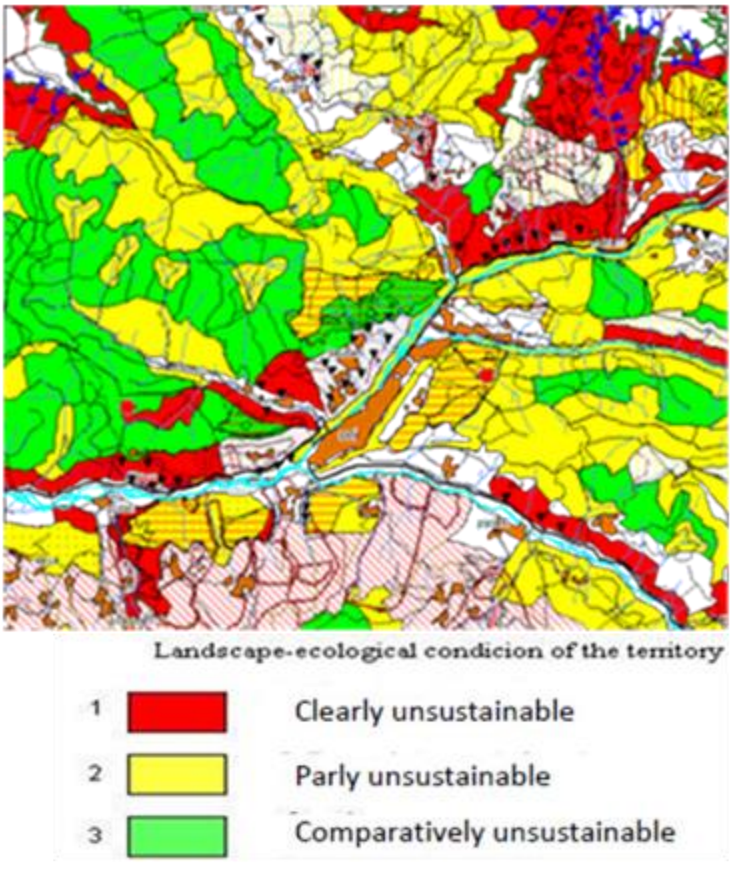


Fig 7. Fragment - "Semaphore" maps of Oni region

The results are mapped out to make clear reference on landscapes which are grouped in 3 basic groups **-"semaphore" maps** (Fig.7) [28, 31, 32].

On this map ***red color*** indicates the unstable territories. Landscapes in which active geodynamic processes (especially landslides, avalanches) are frequently observed, with more phenomena like an avalanche, erosion of slopes, etc. The cabin of a forest in these landscapes should be forbidden completely.

Yellow color on a map shows rather less unstable landscapes. The opportunity of active geodynamic processes in them is essentially less, than in landscapes of "Red group". In these landscapes different forest economic actions can be made. However these actions and especially cabin of a forest should be carried out with extra care.

The ***gren color*** on a map of a landscape-ecological carcass shows territories with rather sustainable landscapes. In them it is possible to make all cycle forest economic actions.

Landscapes of Oni region mainly belong to one class –mountain landscapes. Within the above class of landscapes are identified 4 types: Mountain moderately warm humid type; Mountain moderately cold humid type; High mountain meadows; and Glacial-nival. There are two sub-types within "Semaphore" maps of Oni region the first type. Namely: Lower Mountain Kolkhetian; Average Mountain Kolkhetian. Within moderately cold landscapes are also dentified two sub-types: Average mountain coniferous forests; High mountain forests. Within the landscapes of high mountain meadows are identified 3 sub-types:Sub-alpine;

Alpine; Sub-nival. Glacial-nival types of landscapes do not have any sub-types. Within the landscapes of Average Mountain forests are identified two classes. In other landscapes there is represented only one class.
In Oni region there are 10 genus and 48 species of landscapes are allocated. For comparison: 72 genus and 260 landscapes species are allocated throughout Georgia. Thus, in the region with less than 2% of the total area of the country, 10-15% of Georgian landscapes will be allocated.
Except for "semaphore" maps on which stability of landscapes is shown by a principle of a semaphore (red - yellow - green color), at the **landscape-ecological approach** is made also a "green" map [9].
On **"green" map** dark green color shows sites with the high biodiversity, especially valuable in the ecological plan. Brightly green color the shown intermediate sites between high and low value of a biodiversity. On the contrary, grey color (marsh color) shows sites not representing the big interest from the point of view of a biological variety. It is natural that optimum management should take into account a degree of a biodiversity and that, especially valuable sites should be kept and in them protected territories should be organized.

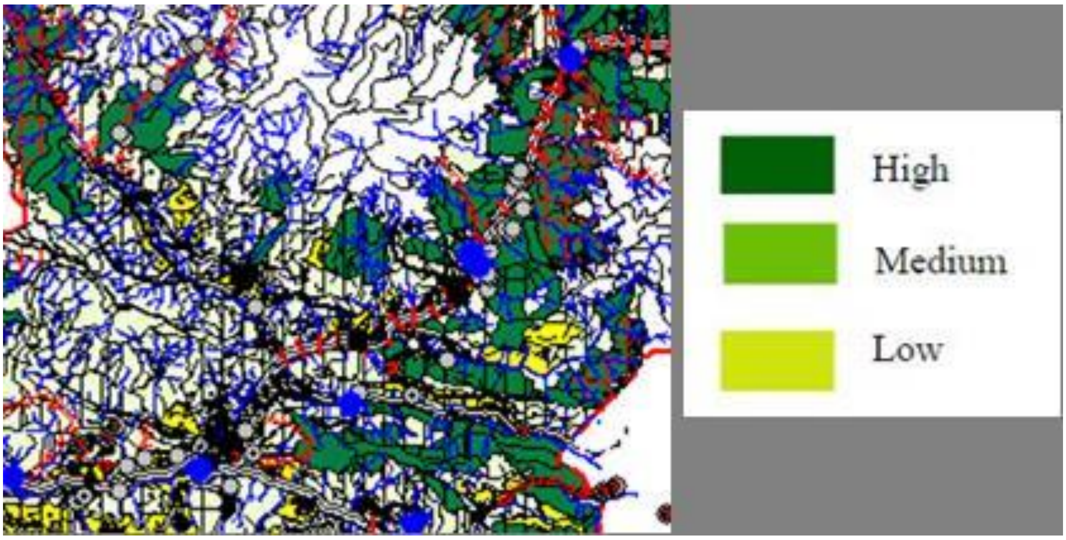


Fig. 8. Green map of Oni District. Landscape diversity

On the map territories of comparatively high biological and landscape diversity are indicated in corresponding signs. Here we also represented Pristin areas of Oni region. Virgin landscapes by N.N.Beruchasvili [18, 19, 20, 28, 31, 32] are unique natural complexes that represent the natural areas least affected by human economic activity. These landscapes ensure the survival of the most vulnerable plant and animal species. Here, forests, one-of-a-kind mountain meadows, marsh tracts and other ecosystems are preserved in their virgin state. These landscapes are uninhabited by humans and unmarked by roads or highways, and thus serve as the most reliable reservoirs of clean air.

Why protect Georgia's virgin landscapes? The virgin landscapes of Georgia are especially valuable because of their rich biodiversity and uniqueness. They are the fundamental natural wealth of the country. Forests cover about 38%, of which a small percentage is virgin. The ecosystems are diverse, ranging from sub-alpine to flood-plain forests, ect. By the beginning of the 21st century, virgin landscapes were preserved only in a few geographical locations, including Europe's northeast, the Caucasus, and Georgia (N.N.Beruchasvili, 2000, 2012, 2015, 2017) [18, 19, 20, 28], (Fig. 9).

Such landscapes are located on the South slopes of the Central Caucasus, near estuary of rivers Rioni, Chanchakhi, Meleshura and Chruchula, Shoda-Kedela and Potskvrebi ridges. At present volume of Pristin forests of the region is increasing. This is caused by depopulation and economic hardships, as population cannot reach some gorges of the region. Most paths and roads are non-existent now. Thus, in Sakaura estuary 10-15 years ago was a path, which connected village Khideshlebi with the river estuary. Now this path does not exist anymore and it is almost impossible to get there from the village.

As to the pseudo-Pristine Landscapes, to them belong 64-th landscapes with secondary pine-Oak forests, which are almost intact. Here of the territories of former settlement naturally appeared Oak-Pine forests which are way out of human activities. The scientific result of our work is a compiled map of potential virgin landscapes of the Georgia, a, also separately for the Oni district.

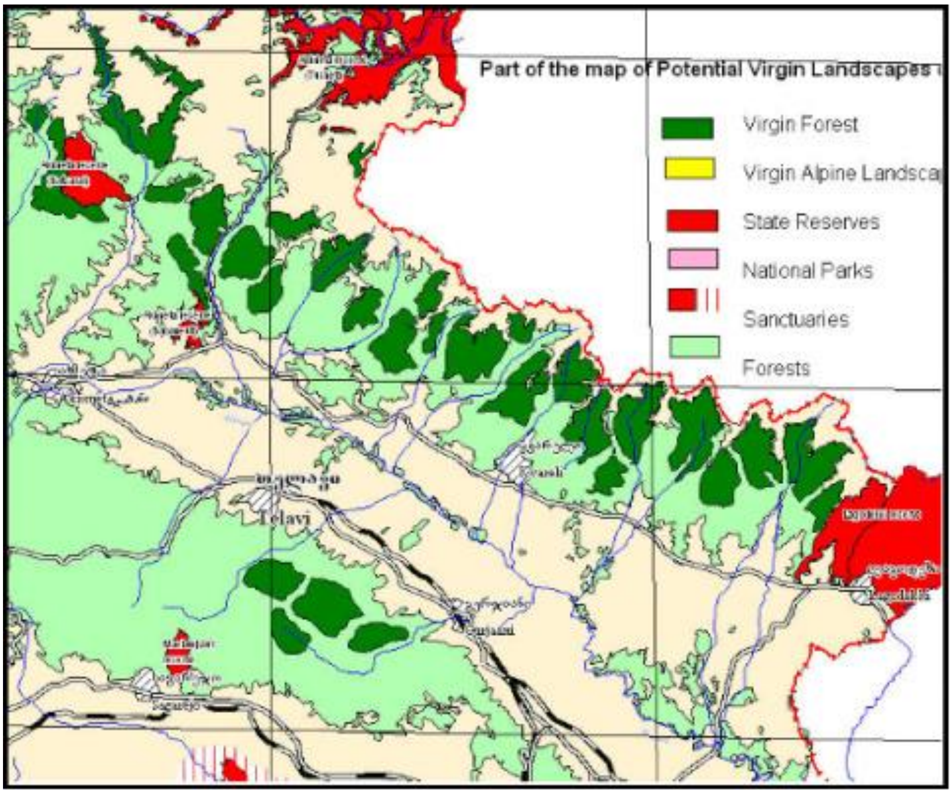


Fig. 9. Part of the map Potential Virgin Landscapes Georgia (By N. N. Beruchasvili)

The basic scientific result of our work is a set of recommendations elaborated for zoning of Oni region into protected areas (Fig.10.).

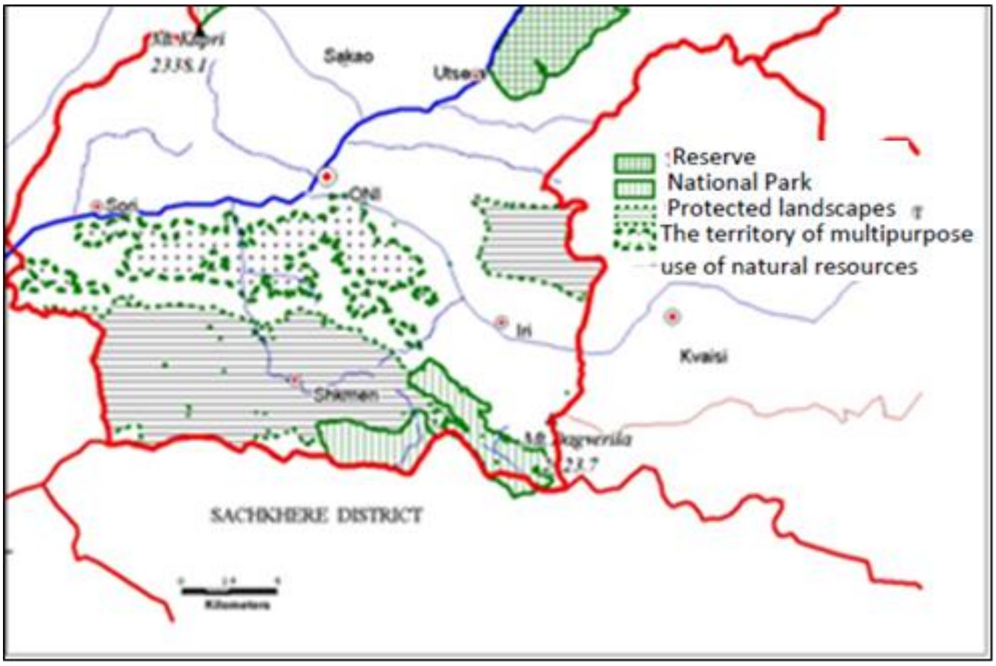


Fig.10. Map of the integrated system of the Protected Areas of the Oni District

A potentially possible National Park in mountainous Racha is recommended to be established. Conditional name of this potential park is “Racha Mountain National Park”. Within the territory of this park the following 4 zones can be identified: 1. zone of strict protection; 2. wild life zone (visitors); 3. zone of traditional usage; 4. zone for restoration. Were discusses various options for creating an integrated system of protected areas, and provides specific examples. In figur 10 shows the Map fragment of the integrated system of protected areas of the Oni District.

Among the mountain-forest landscapes in terms of biological and landscape diversity of greatest interest is the gorge Rioni between Utsera and Saglolo. Utsera-Saglolo mid-mountainous landscapes with beech – dark coniferous forests found spread there and Shoda-Kedela High Mountain-Forest Landscapes. Large landscapes of virgin forests have been preserved in this landscape, it has a high recreational value, and here lies the resort of Utsera and the Oni-Shovi highway, with beautiful landscapes opening from its route. No less interesting is the Chanchahi-Notsarula area. The third section is characterized by high biological and landscape diversity stretched in the meridional direction from the headwaters of the Rioni River to the harbor of the Sakaura River, ect.

Conclusions

Biodiversity of landscapes was studied. Maximum biodiversity is connected with karst regions of high mountain sub-alpine landscapes. It is interesting to state, that due to human activities absolute indicators of biodiversity are increasing, while relative indicators are decreasing.

Landscape structure of the region was studied. We identified 10 genus and 48 species of landscapes. On the map of NTC (Fig.7.) we reflected 1500 NTCs. On the research territory we studied 300 landscape sites (plots). During identification of landscapes based on altitude zonality the orographic, lithological and climatic barriers played important role.

Mountain depression and lower erosion-accumulative landscapes with mixed forests, composed of Oak, Hornbeam and Beech (designated as 64-th landscape or Racha depression landscape) represent main agricultural lands of the region. Here is located regional center Oni and numerous villages, where more than 80% of region's population is concentrated.

Pattern of spread of landscapes was analyzed. We studied it based on the research, carried out in dark coniferous forests of high mountain landscapes. Conclusion was drawn that spread of these landscapes is connected with climatic barriers and paleo-geographical factors. We offered new descriptions for Zemo Racha depression landscapes (Fig.10a.) [28].

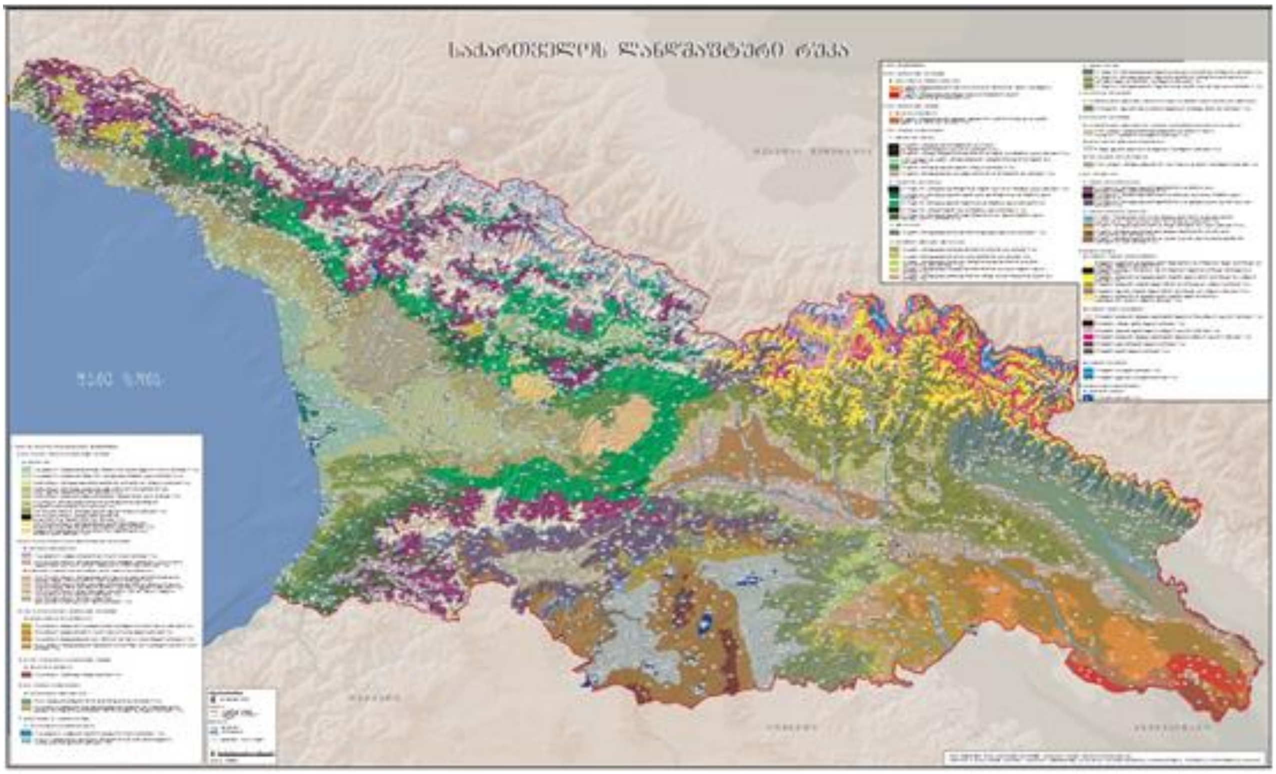


Fig. 10a. New landscape map of Georgia [28]

Geophysics and ethology of Oni region landscapes was studied. Most phytomass (over 500 t/ha) was characteristic to average mountain forest coniferous landscapes. Less phytomass was registered in mountain plain and high mountain landscapes (50-150 t/ha). Landscapes of average mountains have average indicators of phytomass. We concluded that secondary complexes, created due to activities of men might have more phytomass, than so called climatic communities.

With the purpose of elaboration of practical recommendations we identified the following:

- Main landscape-ecological indicators, recreational value of landscapes and their uniqueness. For each landscape we compiled a special form, which contains landscape-ecological recommendations.
- We obtained data, relevant for elaboration of recommendations on establishment of network of Protected Areas. Were identified ecocide territories which must be restored.

Apart from the above data which is directly related to landscape-ecological carcass of the region, we obtained other important information:

- Comparison of topographic maps drawn in 1989, 2000 and 2010 - 2012 and results of satellite imagery revealed that during this period areas covered with forest have expanded. This is caused by decrease of population and deterioration of economic conditions and lack of paths and roads.
- Expansion of forests is observed at the expense of such species, as Pine, asp and others. At certain occasions more productive stands are formed.
- At the same time on accessible territories forest is cut more intensively.
- We identified two areas, where due to the above problem geodynamic processes were developed.

Based on the analysis of the results of conducted research we can plan measures and scientific research to be carried out in future. It may be the following: Creation of computer topography base for Oni region with scales 1: 10000 and 1: 25000.

Georgia is a small country not rich in minerals, however, Georgia has an important natural resource, consisting of its biological and landscape diversity. In terms of landscape diversity, Georgia is ahead of not only all European countries, but also occupies one of the first places in the world. If tropical countries are characterized by a great diversity of the species composition of the plant and animal world, then in landscape relation they are more monotonous and significantly inferior to Georgia in this respect.

Nowhere in the world is there such a diversity of landscapes in such a small area - *Georgia is rightly called the "Landscape Laboratory of the World".* Cultural landscapes with traditional forms of land use and rich cultural heritage are another important resource of Georgia. Georgia’s unique landscape and biological diversity are the most important natural resource of our country.

Rational use of these resources can provide great economic benefits. General economic estimation of the benefits of using these resources has not yet been made, but calculations using specific examples provide convincing results. For example, the economic benefit from systematic logging in the Oni region will be lower than the benefit that will be obtained from the functioning of the tourist and mountaineering center in this region.

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with is detailed legend. The map and a Book: Georgia Landscape Map and Geographic Information System, 488 p. were prepared and published. It should be noted that such a scale survey has not yet been produced.

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ANTHROPOGENIC FACTORS CONTRIBUTING TO THE ECOLOGICAL CONDITION LANDSCAPES IN THE MINING ZONES OF IMERETI AND RACHA

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Abstract

A comprehensive landscape study was carried out in the coal mining area of Tkibuli-Shaori and the teschenite mining area in Kursebi. The article describes changes in the landscape, soil and vegetation and their specific ecological properties in the mentioned areas. A large scale map (1: 50 000) of Tkibuli Municipality has been designed with GIS by drawing on literature, expedition materials, satellite and aerial images and topographical maps. Zones of ecological stress have been revealed. Significant transformation of relief, intensification of geodynamic processes (landslides and mudflows) and groundwater contamination were identified as top risks related to coal mining. Open cast teschenite mining in Kursebi results in a high number of technogenic pits deprived of soil and vegetation and in low quality anthropogenic landscapes. The following anthropogenic impact zones can be distinguished: 1. A severe impact zone where vegetation and soil are completely destroyed and changes in micro-relief, and consequently in climate, trigger landscape transformation. 2. A zone adjacent to a mining site. 3. A transitional zone between post-mined and natural landscapes which is partially destroyed and altered.

Key words: Anthropogenic factor, Ecological condition, landscape, Mining Zone.

Introduction

The mining works carried out in ore mining complexes are geodynamic, geochemical, physical, technogenic and other kinds of reasons of the influence on the environment. Such activities cause dramatic changes in the environment of the ore mining areas in mountainous regions. The region of Imereti is under strong anthropogenic pressure. In this regard we should note the manganese ore in Chiatura, the coal ore in Tkibuli, the teschenite ore in Kursebi, the marble quarry in Salieti, the white and colour stone quarries in Eklari and etc. There is extremely hazardous situation on the territory adjacent to the arsenic ore in Lukhuni. The ecological assessment of the landscapes includes versatile studies of the landscapes, the analysis of their quantitative and qualitative characteristics, determination of the tendencies in the variation and development of the landscapes after anthropogenic impacts.

Materials and methods

During the studies we mainly used complex physical-geographical, cartographical, field and GIS analysis methods. We distinguished the morphological landscape units on the basis of the field materials obtained in 2016-2018 and the analysis of aerial and space photos and topographic maps. For the construction of the landscape map we used GIS technologies as ArcGIS and applied aerial photos from Google Earth.

Results and discussions

The main object of our landscape-ecological study was the Tkibuli-Shaori coal ore and the Kursebiteschenite ore in the mining industry regions of Imereti and Racha.

The Tkibuli coal ore was discovered in 1825 and its exploitation began in 1846. The active reserve of the coal is 307 million tons and its general geological reserve is approximately one billion tons. During the century and a half long history of coal mining its highest output was recorded in 1958 when 3014 tons of coal was mined out (Fig.1). It was 603 times more than the one in 1997 when the output of the ore mining was the lowest (5 thousand tons) [1]. It is obvious that during this long-term period (172 years) an anthropogenic impact on the environment was intense. Moreover, it is important to take into consideration the physical-geographical conditions of the ore site as far as the seismic activity, complicated geological structure, steep sloping of the relief surface and air humidity in the region make the intensity of the impact on the environment higher.

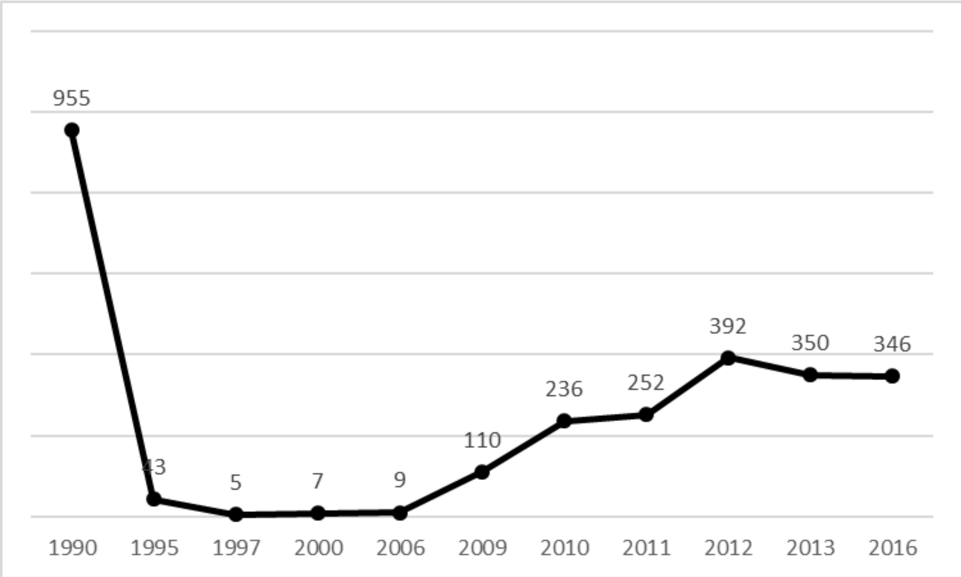

Fig.1. Coal mining output in Tkibuli coal ore

The Tkibuli-Shaori coal ore is situated on the territories of the municipalities of Tkibuli and Ambrolauri. Approximately 75% of the general reserve of different kinds of coal revealed on the territory of Georgia comes on the Tkibuli-Shaori coal ore. The Tkibuli part of the Tkibuli-Shaori coal ore, which includes the town of Tkibuli and its vicinities, is mainly characterized with hilly relief and is located on average at 700-800 m above sea level in the Tkibuli Hollow (in the north-east part), which covers the basin of the river Tkibula in its upper and middle reaches. The hollow is surrounded with the southern slopes of the Nakerala Ridge (the branch of the Racha Ridge). It is built of Jurassic sediments, Bajocian porphyritic suite, Bathonian slates, coal suite, Lower Cretaceous sediments.

The Shaori part of the Tkibuli-Shaori coal ore is situated in the Shaori Hollow of tectonic genesis. Its surface is located at 1000-1200 m above sea level. The hollow surface is less fragmented and its central part is occupied by the Shaori Reservoir nowadays.

The charcoal suite has precipitated parallel to the Nakerala Ridge and has 33-45° inclination and as it sinks deeper in the direction of the slope the inclination gradually decreases to 20-25° [2]. The charcoal-bearing horizons are situated at different depths from the surface, namely in the south-west of the vicinities of Tkibuli town the charcoal layers are observed on the surface, whereas on the surface of the Nakerala Ridge they are located at 1600 m depth and on the Shaori Hollow such horizons are observed at 300-700 m depth from the surface.

The study territory is mostly covered with forest flora with abundant tall timber terrace formations. Oak, hornbeam and chestnut trees are observed in the lowlands and in the midlands we meet beech and dark coniferous forests.

The relief mainly consists of low mountains, at some parts – with middle size mountains. It is characterized with hilly structural-erosive genesis, intensity of landslide-karst processes, mudflow jut cones, erosive hills, landslide forms, coal suites, transformed anthropogenic relief. The absolute altitudinal levels vary from 529 m (the southern part of the hollow) to 1570 m (the mountain Tskhrajvari). The climate is maritime subtropical damp with moderately cold winter and warm summer. The average annual temperature is 12°C; the annual quantity of precipitations is more than 1400 mm [3]. The bottom of the hollow is crossed by the river Tkibula and its numerous tributaries.

The landscape background is mainly presented with hilly erosive-denudational landscape with hornbeam and oak trees, oak and chestnut forests and evergreen undergrowth in the foothill and low mountains.

The Tkibuli part of the Tkibuli-Shaori ore, where the charcoal is mined, covers approximately 40 m^2.

In the past (the 40-s of the XX century) the charcoal was extracted from open cast mines in Tkibuli. Therefore, there are many small secondary artificial holes with the depths of 25-30 m and length of 12001500 m. The areas of each of them are 9 ha [4].

In the ore mining region of Tkibuli not only individual components of the nature are under anthropogenic pressure but the whole landscapes as well. In order to make the analysis of the interaction of the technogenic activities and nature and the assessment of the ecological state in the industrial complex we constructed a large-scale (1:50 000) landscape map (Fig. 2) in GIS technology. The map expresses the location of the modern landscapes and their spatial interrelation.

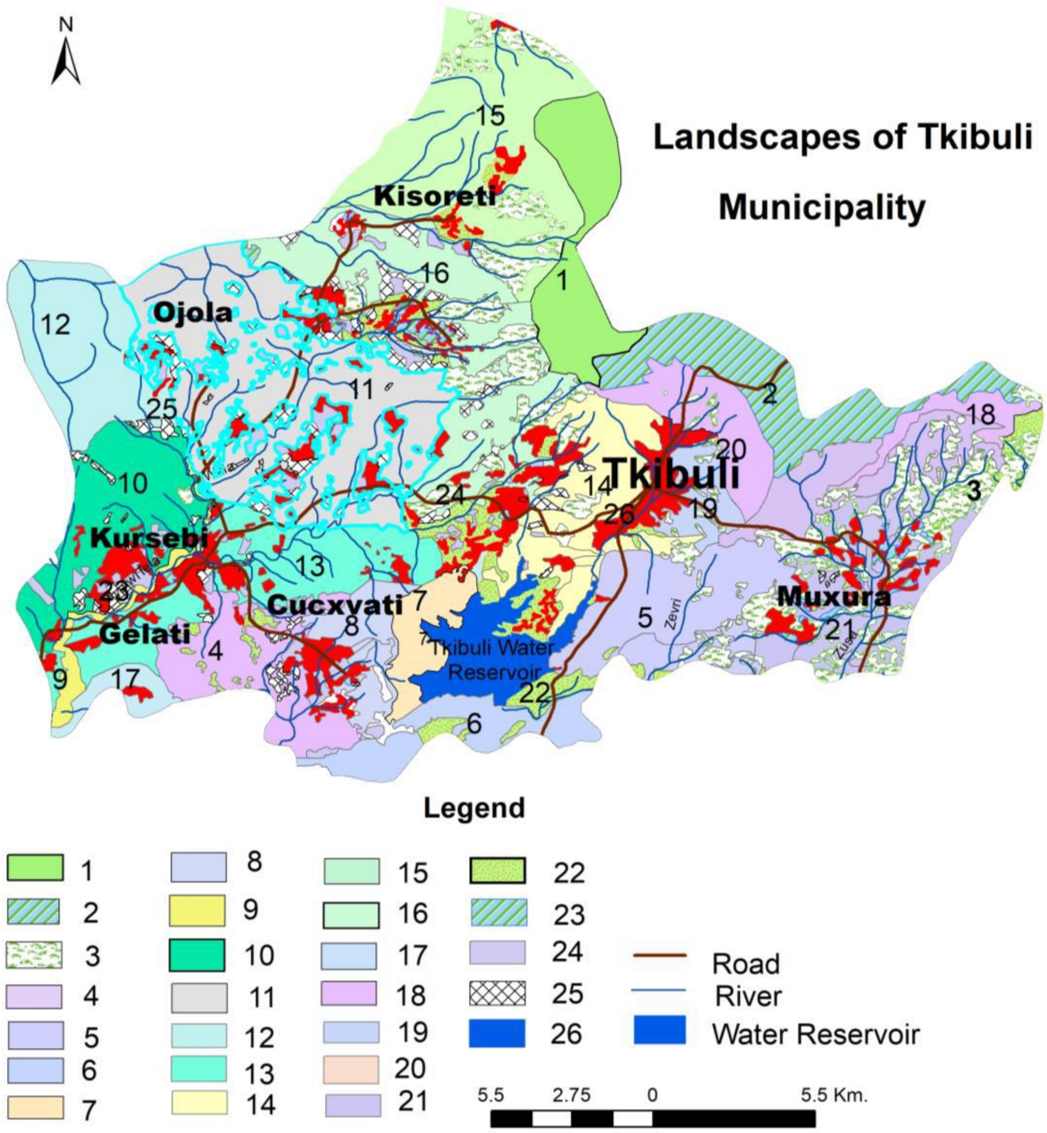

Fig. 2. Landscapes of Tkibuli Municipality [2, 5]

Landscapes: 1. The middle-size mountains with steep slopes and dark grey, at some places extremely washed off forest soils, beech and hornbeam trees; 2. The limestone cliffs; 3. The former forest sites, secondary meadows used as pastures; 4.The foothills with beech, oak and chestnut trees; 5. The low mountains with steep relief, at some places – collapsed reliefs, humus-carbonate soils; 6. The foothills with limestone quarries; 7. The hollow built of sandstones and slates in a charcoal suite, erosive and landslide-accumulative relief forms; 8. The quarries of facing stones (teschenite), yellow soil, agrolandscapes (orchards, maize fields, vegetable gardens) and populated landscapes; 9. The karst cavity with a low mountain relief; 10.The hilly relief with wide gorges, cliffs, landslide forms; 11.The steep relief with karst forms; 12.The sloping valleys of the hollow with an artificial lake-reservoir, elements of Colchis forest, evergreen and deciduous undergrowth; 13.The low mountains with steep cliff relief with a coal suite, narrow and deep erosive gorges, river rapids and waterfall segments; 14.The low-mountain, extremely disintegrated erosive landscape relief with landslide phenomena; 15. The hollow with an anthropogenic relief with the quarries of building materials (teschenite, basalt, diabase, brick clay, etc.) and brown coal; 16.The cliffy slopes of the ridge with thick limestone layers; 17.The flat plateau of a ridge with numerous karst forms; 18.The ridge slopes built of limestone with a network of river gorges (Tkibula, Tskaltsitela, Chala, Lekhidari), with dark grey soil and chestnut and hornbeam trees; 19. The cavity with landslides and erosive, hilly-wavy relief with limestone around, abundance of beech and chestnut trees, Colchis undergrowth. 20. The limestone low mountains with beech and chestnut trees, brown forest soils. 21. Basin with landslide-erosive relief and the limestone cliffs, agrolandscapes (orchards, maize fields, vegetable gardens) and populated landscapes, humus-carbonate soils, oak and hornbeam trees; 22. Vegetable gardens; 23. Vineyards; 24. Fruit gardens; 25. Tea plantations; 26. Water reservoir.

As a result of the anthropogenic impact the ecological states of the landscapes are deteriorated due to landslides, torrents, erosive processes, forest clearing. The relief is greatly transformed and its surface is extremely inclined. At the same time the territory is distinguished with intense landslides that in their turn decrease the stability of the relief.

Taking into consideration the large-scale hazard and intensity of landslides in Georgia the areas of Tkibuli Municipality presented as Jurassic sediments and Tertiary clay rocks are characterized with considerable coefficient of damage (K0 0.5-0.7) and according to the coefficient of the damage caused by mudflow processes it belongs to the regions of major (0.5-0.3) and moderate (0.3-0.1) hazards. In the natural-territorial complex in the foothill of the southern slope of the Racha Ridge there is a high risk of probable mudflows and consequently, the coefficient of the probable damage of the territory is K0 0.5-0.8 [5].

The landslide processes are aggravated by the influence of technogenic factors. Its role is especially obvious in the development of anthropogenic landscapes, when almost every component creating the landscape undergoes considerable changes. On the low stability territories there are maximum load technical impacts. The technical influence on the relief nature causes disintegration in the natural surfaces and contributes to formation of new technogenic forms of the relief: anthropogenic-denudational pits, ditches, waste banks, mine dump. Besides, quite often there are funnel-form sloughs at the tops of abandoned quarries, which are caused due to the damage of the walls and cave-ins in the mines, etc. In the 70-s of the XX century the vertical bedding of the relief surfaces in the areas of mines “Nakhshira” and “Aghmosavlet 2” reached 90 cm on average and the maximum bedding exceeded two meters (Fig. 3). In certain areas the maximum vertical bedding of the surface caused by underground works during the whole period of their exploitation is 10-15 mm and the horizontal shift reaches 1.3-2.4 m [6].

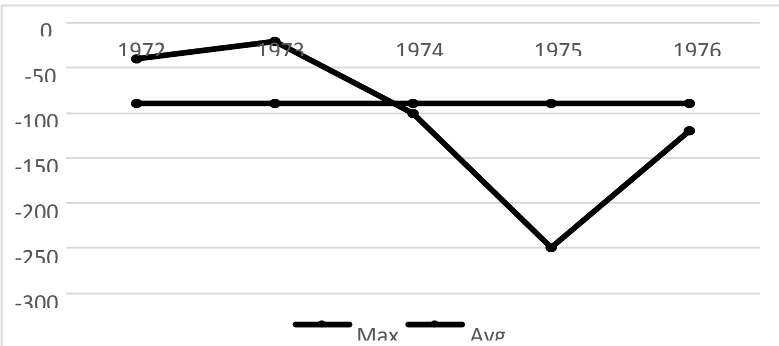

Fig.3. The vertical bedding of the relief surface in the areas of mines

Intense erosive processes are taking place on the rock refuses, which have 25-40° inclination. These processes are aggravated due to heavy rains, disintegrated rocks and steep sloping. The 10-20-year-old sloughs have already been covered with vegetation and most frequently cannot be distinguished from the natural forms of the relief.

The industrial explosions in the mines in seismically active regions are the reason for triggering local earthquakes and dynamic mining phenomena. The explosions resulted in seismic waves create additional tension in the active foci zones. On the territory of Tkibuli, aggravated ecological state is characteristic of the foothill and lowland landscapes of the southern slope of the Racha Ridge, the southern slopes of the Nakerala Ridge in the midlands, the sources and confluence of the rivers Tskhrajvari, Mukhnariskhevi, Sabilasuri. Consequently, low stability of the landscapes is observed on the above mentioned territories.

Anthropogenic factors have significant impact on the development of karst processes. It causes formation of new fissures and activation of karst processes. The vegetation cover has considerably changed. In the river gorges there are thin lines of alder forests and willow and aspen trees. At some places the oak and hornbeam forests have degraded and are characterized with nature of derivatives presented as oriental hornbeam, dogwood, maple, medlar and etc. In comparatively well preserved places oak and hornbeam trees are presented. The process of mining works disturbs the regimes of underground and surface waters, which is the significant factor in creating landslides in the ore area. On the quarry slope the aquifer horizon is draining. Then it is followed by deformation and bedding of the cover layers and fissuring of the surface. As it makes favourable conditions for landslide formation, the surface water leakage accelerates the landslide movement.

As a result of a morphometric analysis of the relief of the Tkibuli Hollow, namely, calculating the areas of the reliefs, which have different inclinations, we determined that the most area – 48% is occupied by midstability (surface inclination – 15-45°) territories. The area is mainly occupied by the Lagori Mountains (745 m) in the west and the slopes of the Gormukhuli Mountain (992 m) in the south of the hollow. In the west it is presented as the gorge slopes of the rivers Tkibula and Satsiristskali. Comparatively less area – 22% is occupied by non-stable (surface inclination – more than 45°) territories. These are the northern and eastern parts of the Tkibuli Hollow (the limestone slopes of the Nakerala Ridge), which include the gorge slopes developed in the low and middle mountains. 30% of the area is covered by stable (surface inclination – 015°) territories, which are presented as the bottom of the Tkibuli Hollow, the lower reaches of the river Tkibula, populated areas: Tkibuli town, the territories of villages Satsire, Dzirovani, Dabadzveli and also Samtredia. These territories can be grouped as three types of areas: stable, mid-stable and non-stable.

In the conditions unsteady for the relief certain ecological problems have been arisen and they are considered the main ecological risk, which is hazardous for the environment. These are: fundamental changes in the relief, activation of geodynamical processes (landslides, mudflows), contamination of surface and underground waters (Fig. 4).

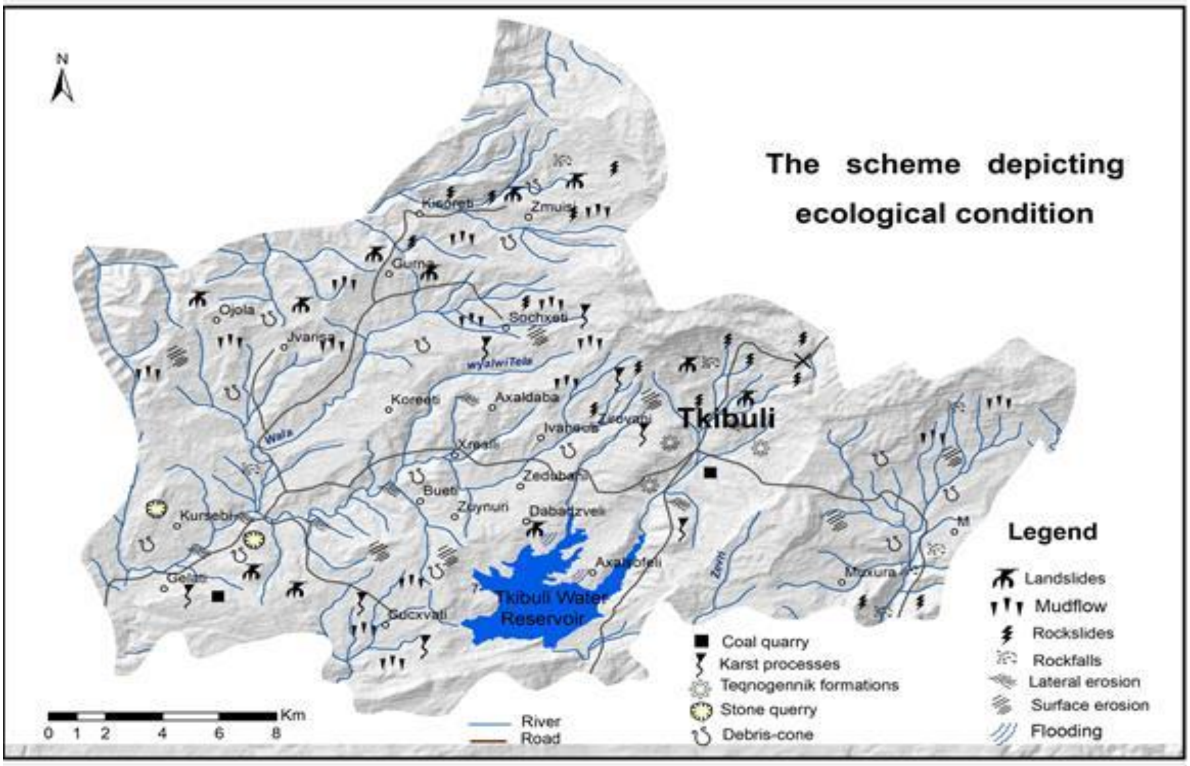

Fig. 4. The scheme depicting ecological condition of Tkibuli Municipality

The Kursebi teschenite ore where facing stone is extracted, is situated on the territory of village Kursebi in Tkibuli Municipality in the Kursebi Hollow (length: 3.5 km, width: 2-2.5 km). There is a vein of outcropped teschenite here. Its maximum thickness is 100 m. In the Kursebi Hollow the teschenite is extracted from an open cast mine. Therefore, the subtropical yellow, humus-carbonate type soil, which is covered with hornbeam, oak, chestnut and beech trees and with holly, azalea, hazel nut, hawthorn, etc. in the undergrowth, is being removed. Consequently, there are only left outcropped rocks, technogenic caves without any soil and vegetation cover and low quality anthropogenic landscapes (Fig. 5).

Fig. 5. Kursebi teschenite ore

On the basis of the large-scale landscape study of the territory of the Kursebi teschenite ore we distinguished following zones of anthropogenic impact: 1. the maximum anthropogenic impact zone, where the vegetation cover and soil are entirely destroyed. The microrelief is changed, consequently the microclimate and the whole relief have also changed; 2. The zone, which is located immediately in the area adjacent to the ore mining; 3. The transitional zone, which includes the territory between the ore mining area and natural landscape, though contains already affected and changed landscapes. Here, unlike the two former zones the degree of change in landscapes is insignificant and it is possible to restore the natural interaction between them. Thus, the main factor in the change in landscapes appears to be biogeomorphological factor, as far as first of all, the relief and soil-vegetation cover is changed here.

On the territory of Racha in Ambrolauri Municipality, a major problem is the Lukhuni arsenic ore, where extractions began in 1933 and the arsenic was processed from 1937 at the ore mill in village Uravi. In 1993 the industrial complex stopped functioning and nowadays on the mill territory 110 thousand tons of arsenicbearing material is stored and scattered. The general content of arsenic is 4-5 thousand tons. In "Mepischala" burial ground, allocated for $6000m^3$ wastes, nowadays 600-700 tons of industrial waste brought from different parts of the mill is placed. The part of the cover of the burial ground is damaged and atmospheric precipitations are reaching inside. The torrents caused by precipitations fill the sedimentation chamber. Consequently, the arsenic-bearing material is flowing out of the burial ground and contaminating the environment. The industrial arsenic wastes mainly appear in the soil and water. The highest level of contamination is observed in villages Uravi and Likheti located in the gorge of the river Lukhuni. The arsenic content is considerably high 1500-29000 mg/kg on the territory of the mining-chemical factory in village Uravi. It is also high in the soil in the territory of the sarcophagus of the old mill. In the water of the river Lukhunistskali the arsenic content does not exceed the permissible concentration level and in the bed residuals the arsenic content is 18-200 mg/kg [7]. The contamination distribution area alongside the river gorge covers tens of kilometres and it reaches several kilometres perpendicular to the gorge. There is a great danger of contamination of the pastures and agricultural lands by the arsenic. It will make the food products useless and put the human health under danger.

Conclusions

Certain ecological problems at the Tkibuli Hollow, which were created in non-stable relief conditions during ore mining, mainly as an ecological risk hazardous for the environment, first of all are:

- A substantial change in the relief;
- Activation of geodynamical processes (landslides, mudflows).

Pollution of surface and underground waters is also a problem. The pollution areas become more hazardous in the conditions of active geodynamic processes in densely populated foothills and hollows. The exhausted mines are the reason for creating wide network of fissures, which in their turn are precondition for formation of landslides on the steep slopes and rock failures on the slanting slopes. On the southern slope of the Nakerala Ridge on the open cast mining territories new landslides are being formed and old fossilized landslide bodies are being activated.

The decrease in the forest and meadow landscapes as a result of technogenic impact contributed to dramatic intensification of exogenic processes (landslides, avalanches, earthfills), which in their turn caused displacement of huge soil masses on the steep slopes. It caused change in the tense state of the rocks, also decrease in the solidity of the rocks due to the removal of the slopes.

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ON THE EVOLUTION OF KARST CAVES IN THE CONDITIONS OF PLATFORM KARST (ZEMO IMERETI PLATEAU CASE STUDY; GEORGIA)

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Abstract

The actual materials obtained as a result of our studies carried out during years in the ZemoImereti Plateau, namely, the morphological analysis of karst caves, hydrological-hydrogeological studies, results of tracing (indicator tests) of underground waters, borehole data and others, allow us to prove that the influence of phreatic, vadose and dry epochs has been reflected in the evolution of caves. An important part of karst caves has undergone the phreatic stage of development, though nowadays the traces of pressured flows in most cases have been erased by impact of vadose waters and other processes (corrosion, destruction, formation of speleothems, etc.). It is being also identified that the process of evolution of caves is not similar within the same karst massif that is related to the violation of the normal course of cave development by the influence of tectonic movements or other conditions.In the modern stage of development, the phreatic regime is well expressed in the Ghrudo underground basin, and the traces of both the vadose and dry epochs are well preserved in the higher located caves that went through the cycle of development. The periodic streams play an active role in the next stage of cave development, which, in turn, has been reflected in cyclical nature of sedimentation.

Key words: Hydrogeological studies, indicator tests, cave development cycle.

Introduction

The occurrence of karst cavities remains a topic of discussion so far. One group of researchers gives preference to the occurrence of caves only in the phreatic zone (Grundi, Devisi, Savitski, etc.), the second group – in the vadose zone (Kattseri, Marteli, Lemani, etc.), but most researchers believe that the cave occurrence begins in the phreatic regime of waters and ends in the vadose (Trombi, Korbeli, Maruashvili, Gvozdetski, Maksimovich, etc.).

Issue of discussion is a reference to the leading process (agent) in the cave-occurrence. One group of researchers thinks the leading agent is a pressured or free erosion, the second group – corrosion (nival, mixed, condensation, etc.), and the third group – a joint impact of corrosion and erosion on the karstified rocks, though it remains to be discussed, which one is leading.

Based on our many years' observation and research, it can be said that the occurrence of the caves takes place simultaneously in the zones of depth circulation, full saturation (phreatic regime) as well as in the zones of seasonal fluctuation and aeration (vadose regime). Therefore, underground karst forms of relief are developed under the corrosion, erosion (pressured erosion or free erosion) and gravitation impacts in various hydrodynamic zones.

Study Area. ZemoImereti Plateau includes the easternmost part of western Georgia's limestone stripe, which is characterized by peculiar natural conditions (relief, tectonics, climate, surface and underground waters), and is the only karst platform region in Georgia [1, 2, 3, 4, 5].From the relief point of view, it is sharply distinguished from other karst massifs of Georgia and includes a central, relatively high part of the intermountain plain of Georgia. Most of the part of the plateau surface is located at the height of 400-800 m above sea level. It is characterized by deep river gorges and the peculiar soft relief of watershed areas. The uniform surface of the plateau is dissected by the canyon gorges of the Kvirila River and its deep (100-250 m) tributaries into relatively small plateaus with steep slopes and plain surface.

Geologically and structurally the study area as part of the Georgia's block is represented by two structural floors: the Pre-Cretaceous base and the Cretaceous-Neogene platform cover. Paleogeographically the latter is divided into two sub-horizontal sub-floors: Cretaceous carbonate and Neogene terrigenous (Fig. 1).

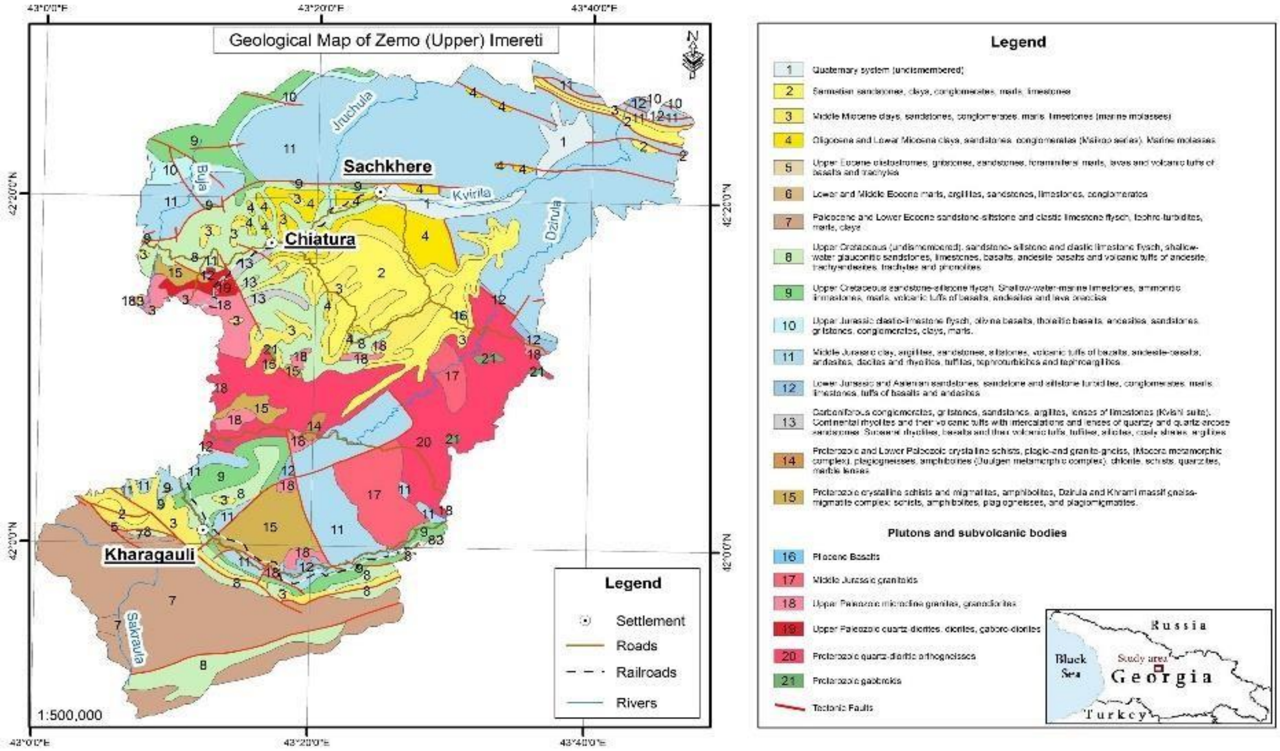

Fig. 1. Geological map of the ZemoImereti Plateau [6].

Research and Methods

In the framework of the research we have used a variety of research methods that are used to study classical karst territories, including: field-surveying, geomorphological, indicator (water tracing method), and many others. We also analyzed the boreholes' data, through which the depth circulation zones were identified.

The correlation of the heights above sea level of karst waters and cave entrances, as well as relative heights of the cave tiers and terraces developed in the individual river gorges were used to identify the epochs of delay of ascending tectonic movements.

Results

The study of factual material accumulated over the years by us in the ZemoImereti plateau, in particular, the morphological analysis of underground cavities, the study of their hydrogeological peculiarities and research of relations of surface karst forms, indicator tests, borehole data, etc., allow us to conclude that the genesis of underground karst forms is closely related to tectonic fragmentation and is carried out simultaneously in the surface and depth of the karst massif. In addition, the more favorable conditions for the cave occurrence are created while the occurrence of concentrated streams that is largely characteristic for the phreatic regime. Such a regime can be established under the main drainage levels and above these levels too.

On the modern stage of development, as mentioned above, the cave occurrence takes place simultaneously in the depth circulation zone, full saturation levels' seasonal fluctuation and aeration zones. Therefore, the underground karst forms of relief are developed under the impact of corrosion, erosion (pressured or free erosion) and gravitation in various hydrodynamic zones. Based on the materials obtained by us, it can be noted that some caves in the study area are on the stages of fissure, hole or channel that is proved by the borehole data [7, 8] and the existence of karst underground streams beneath the river beds [1, 2]. It is known that in the vadose epoch of cave-occurrence, the fissures and karst cavities are discharged from permanent pressured waters and are under the impact of infiltration-influation-condensation streams.Hidrologically it corresponds to the active water exchange or aeration zone.

From the vadose epoch, vaucluse, fissured-corridor, stream-corridor and periodical stream-corridor stages are well expressed in the study area. The vaucluse stage that starts the vadose epoch of development of the cave is a time of substantial changes in the life of the cave. It starts with the opening of the cave, or with the opening of the free exit in its lower ending, which takes the cave flow on the earth's surface, in the normal atmospheric pressure environment. The flow of cave stream increases sharply, which leads to erosion enhancement, destruction and the desire of the cave alongside profile to the balance curve. On the mentioned stage, individual sections of karst cavities are characterized by the phenomena of hard water discharge, especially during the abundant atmospheric rainfalls, when the water levels in the karst cavities are significantly higher. The vadose stage is well expressed before flowing out on the surface in the basins of the Ghrudo, Monasteri, Lezhubani, Tiri, Kldekari, Bondi and other vaucluse streams.

The beginning of a stream-corridor stage is associated with the reduction of intensive mechanical erosion in the cave, which may lead as a result of the development of balance profile or the sharp decrease in flow in the cave. In this stage, the cave corridors and halls are already mainly developed. The most part of the cavity is filled up with air; speleothems are developed intensively; the destruction is underway. The latter may cause the occurrence of pooled lake and the accumulation of clay (e.g., Karianiklde and Ormoebi caves). In the second half of the stage, alluvial and other materials are accumulated. The following caves are in the stream-corridor phase of development: Bochoklde, Shvilobisa, PataraSadatviaklde, Khvedelidzeebisklde, Shekiladzeebisklde, Varsima, Kudurebisklde, Ekvtimesklde, Dzudzuana, Nikrisa and others.

Periodically, the stream-corridor stage begins with the disappearance of permanentstream in the cave. During this stage, periodic action of temporary (related with rain and snow melting) floods takes place. On this stage of development are the important part of the caves in the study area – Samertskhleklde, Bnelaklde, Jikhura, Sachinkia, Piraghiaklde, the part of Rganisklde and other caves.

The vadose epoch is replaced with a dry epoch, which is represented only by a dry-corridor stage. It begins after the disappearance of water flows in the cave.Erosion is stopped in the cave and among the corrosion types the water chemical reactions are preserved that are leaked out on the walls as a result of steam condensation of the warm air flown from the outside. Development of speleothems is stopped. Accumulation of gravitational, remnant, anthropogenic and zoogenic materials take place that ultimately leads to the filling and modifying of the cave.

Fig. 2. a) Jruchula cave; b) Sameleklde cave

The examples of the cave on the dry-corridor stage are Tsona, Jruchula, Sameleklde, Samgleklde, Gvarjilasklde, the front part of Rganisklde, Tsilto III, Ortvlaklde, Ghvitori, Kozmani, Deviskhvreli, Mghvimevi, Bogirisklde and others (Fig. 2).

It should be noted that the above mentioned individual stages of the development of cave continue tens and hundreds of thousands of years.For example, the dry-corridor stage in the Tsona cave had begun 100-

300 thousand years ago (Lower Paleolithic, Acheulian -Moustian), and in the Ortvala cave – 40 thousand years ago according to archeological documents [9, 10, 11].

The sequence of these stages, or the violation of normal process of the cave development, may be caused by tectonic movements, destruction in individual parts of the cave, human intervention and other reasons.

Intensive ascending tectonic movements and short-term delay epochs that have been emphasized by a number of researchers [12, 13, 14], mainly stipulated the step-wise layout of the caves on different stages of development in the ZemoImeteri Plateau as well as the wide distribution of tunnel-type underdeveloped caves. Thus, the caves of Samelekldе and Jupchula developed in high steps in the Jruchula gorge are on the dry-corridor stage, and the Taroklde and Samertskhleklde caves – on the periodical stream-corridor stage.

Khvedelidzeebisklde, located on the lower level, and yet invisible floor below it (the latter is flowing out in the form of pressured water in the bed of the Jruchula River) are on the stream-corridor or vaucluse stage (Fig. 3).

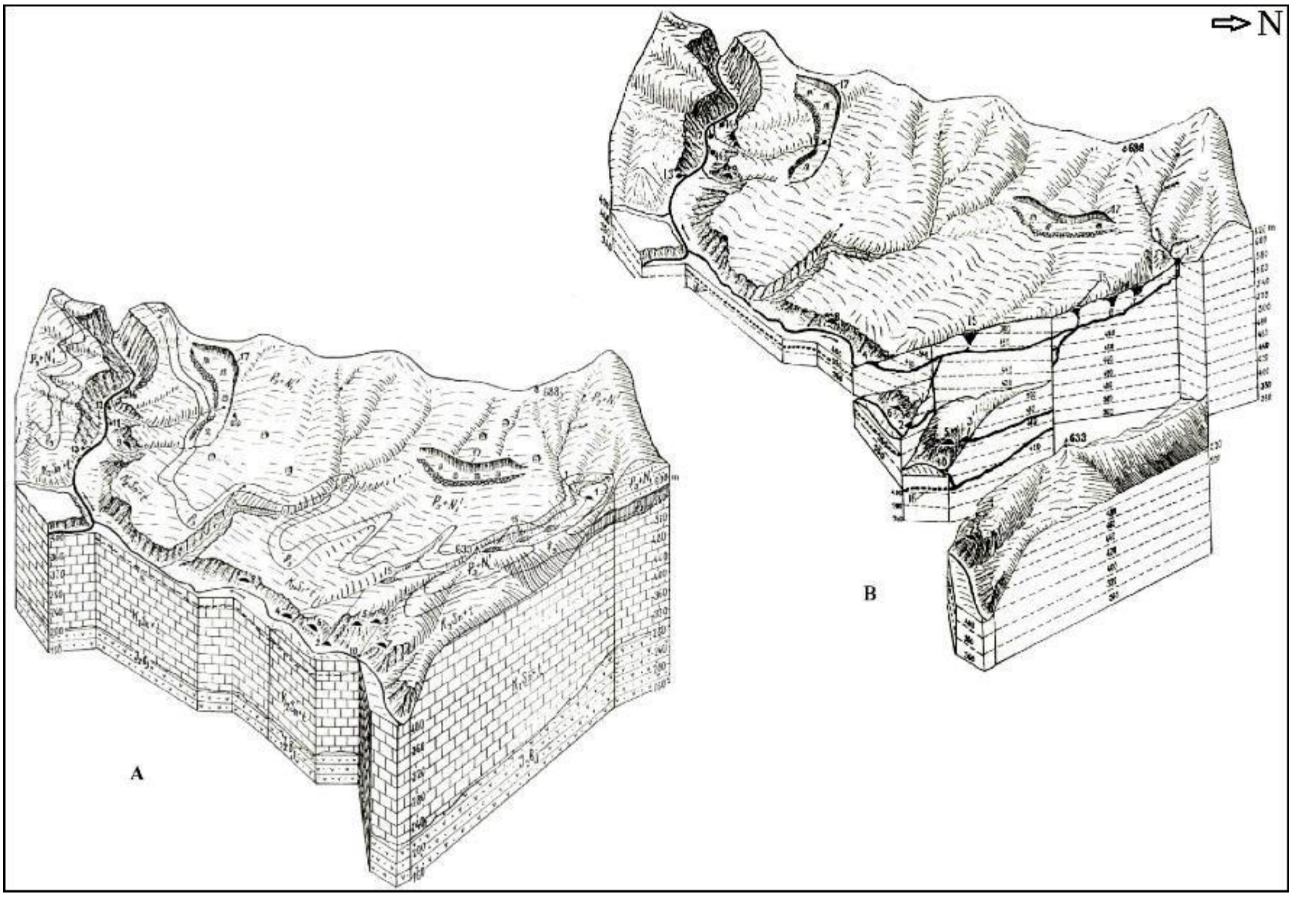

Fig. 3. A) Geological conditions of development of karst events; B) Hydrogeological situation in the Darkveti-Zodi Plateau (block-diagrams).

Intercomparison of absolute altitudes (Fig. 4) of the cave entrances and karst sources, as well as the relative heights (Tab. 1) of the cave tiers and terraced stages developed in the individual river gorges allow us to presume that the epochs of delayed tectonic movements should be at least 4-5.

Different sections in the same cave can be in the different stages of development simultaneously. An example of this is the Shvilobisa cave, where there are sections in the stream-corridor and periodically streamy stages of development. Also, the front section of the Ranganiklde cave is in a dry-corridor stage of development while the further section is in the periodically stream-corridor stage.

The normal process of development of the cave can be violated by human activity. For example, during the field work, we had to witness the filling of the Baratashvilis' shaft and Pirana abyss with the bad rocks of manganese ore. We couldn't find some of the caves (e.g., Kvatia), which were previously recorded and described by us; as we assume, they were filled up with manganese bad rocks.

Table 1.

Altitudinal distribution of terraced stages and horizontal caves in the Zemo Imereti Plateau

Relative heights of terraced stages, m				The relative height of the caves, m						
				River gorges						
In the west of Chiatura (Kuchukhidze, 1986)	Sachkhere vicinities (Devdariani, 1964)	Sachkhere - Chiatura section by field surveys)	Stages	Kvirila	Jruchula	Nekrisa	Rganisghele	Tabagrebisghele	Bogiristskali	Sadzalekhevi
5-10	2-4	4-7	I	Ghrudo-6 Parduli -5	Khvedelidzeebis-klde-4	Bregvadzeebis-klde-7	Lezhubani- 4 (vaucluse)	-	Bogirisklde-5	-
20-25	8-12	15-20	II	Pasieti-12	Samertskhleklde-14 Sareki- 15	Dzudzuana-14 Nekrisa-18	Gvarjilasklde- 15	Sakajekari -18 Namdzlevklde-20	Bogirisklde - 14	-
40-45	20-22	30-40	III	Mghvimevi-35	Jruchula -35, Samgleklde-38, Samertskhleklde (II) -32	A grotto across from Dzudzuana cave-33	Bnelaklde-30, grottos across from Bnelaklde cave-30-40 Ortvalaklde -35-40	Judisa-30-35 Gela -33	Zekha 30-35	Jikhura-33 Sadatviaklde -37
50-60	40-50	50-60	IV	Chipianiklde -50	Taroklde -63	-	Grottos -50-60	-	Bochoklde -50	-
80-85	-	-	V	Ormoebi-75	Sameleklde -75-80	-	Rganisklde -80-85	-	-	Sachinkia-85 Nakhiznebi-82 Sadzrokhia-75

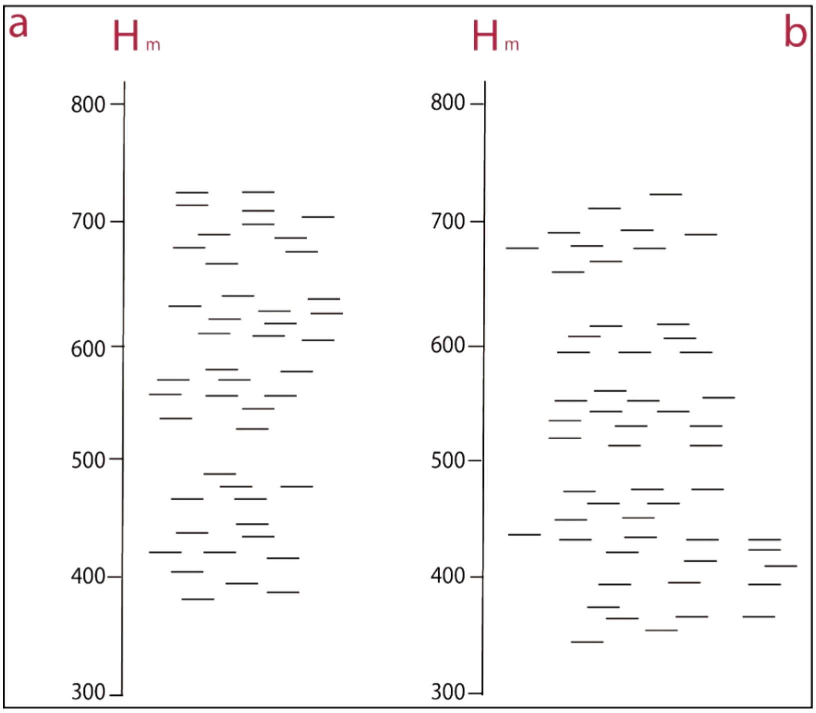

Fig. 4. The scale of distribution of hypsometric levels of horizontal caves entrances (a) and karst sources outlets (b) in the Chiatura structural plateau.

Conclusions

Therefore, considering study of karst caverns and hydrogeological situation, it can be noted that along with the ascending tectonic movements and relief fragmentation of the study area (with short delays) a rapid shifting of karst waters at lower levels (Fig. 2) occurred.All this led to the suspension of the caves development at various stages, and the waters moved in the depths are flowing out in the form of large vaucluse sources, or leaking below the base level and filling up the individual fissures. As it is clear by indicator tests and existing boreholes, there is not only the absorption of waters through the mentioned fissures, but also the movement of their substantial mass, and sometimes they can be discharged in the form of ascending pressured waters in the riverbeds.

At the modern stage, the individual karst caves, shafts, swells and vaucluse sources were the unified in one karst water-containing system. The lower phreatic horizons of the system are inaccessible for human beings.

Thus, it can be said that part of the karst cavities in the study area was originated in the phreatic epoch, though the influence of the pressured waters of this epoch is almost entirely erased by the influence of the vadose waters and other processes (erosion, rockslides, speleothem formation, etc.).The exception is some caves that went through the cycle (Tsilto III, Rganisklde, Samgleklde, Sakajekari and others), where the signs of phreatism (sloping of corridor bottoms in the depth, the corries developed in the ceiling, the smoothed arch, the considerable thickness of the plastic clays, etc.) are more or less well preserved. The effect of free flows is not less important in the origination-development and transformation of caves in the study area, which is indicated by the existence of the materials of alochtonic origin in terrigene sediments of karst caverns [1, 3], the well-expressed dissected micro-meanders (Shvilobisa, Chiatura 100, etc.), etc.

Acknowledgements

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ADVANCES IN DIGITAL SOIL MAPPING (A REVIEW)

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Abstract

Digital mapping of spatial patterns of soil (DSM) types and properties through soil and other auxiliary biophysical data provides merging math and statistic models with field and lab research actively involving Geographic Information Systems (GIS) and Remote Sensing (RS). A number of studies are focused on various directions in DSM. This review paper on DSM reviews 289 issues published in 11 key journals during the calendar years of 2017 and 2018. Papers are grouped by themes to cover 5 subject areas. The themes were chosen by classifying all articles published in a single leading journal for the same period. Themes (in order of number contributing to the total) were: 'Data collection and combination'; 'Methods and models'; 'Mapping scale'; 'Uncertainty assessment'; and 'Applications of DSM'

Keywords: DSM, Remote Sensing, geostatistics, automated mapping,

Introduction

Digital Soil Mapping (DSM) implicates digital mapping of spatial patterns of soil types and properties through soil and other auxiliary biophysical data (topography, geology, climate etc). This system provides merging math and statistic models with field and lab research actively involving Geographic Information Systems (GIS) and Remote Sensing, where topographic data is obtained from DEM through GIS and on vegetation and land use/land cover by classification of the remotely sensed images, which ensured gaining popularity to this mentioned method. The major difference between traditional soil mapping and digital soil mapping is the way how the model derives the soil information from the input data [1]. Much research in recent years has focused on methods and applications in DSM. Existing models and methods are diverse. This review presents articles published in leading journal in 2017-2018. In this case, we are familiar with the 289 issues published in these years. Based on the articles published during this period, we have five main topics that are dedicated to DSM. It turned out that most of the theses on such topics were published in Geoderma. We have reviewed 37 papers published in this journal (Fig. 1).

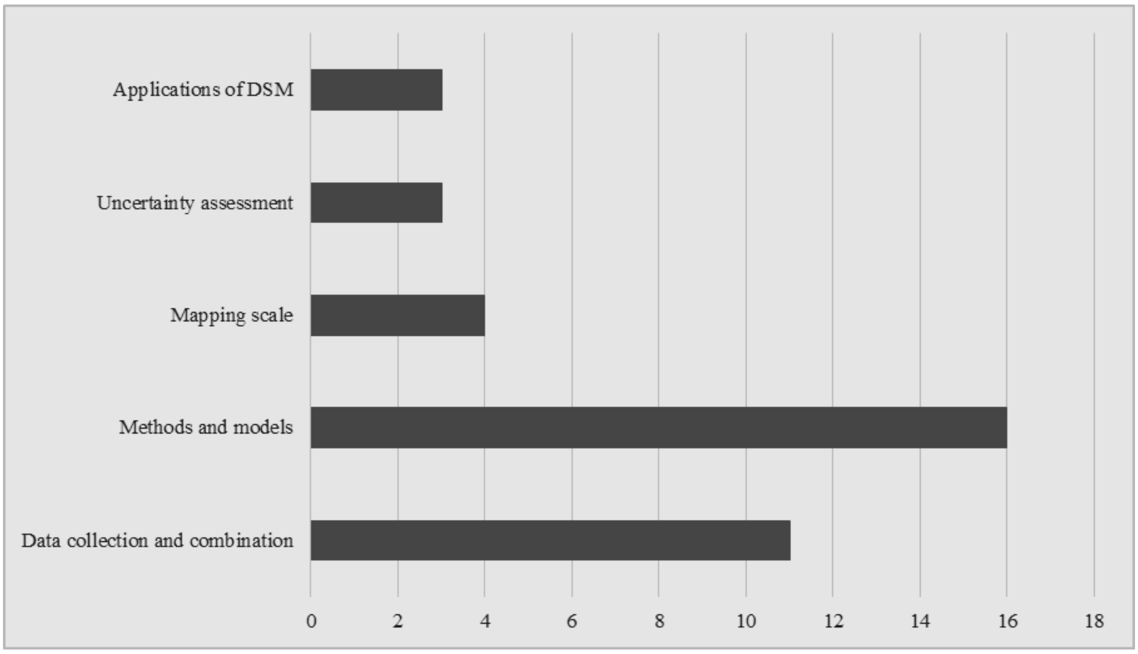

Fig. 1. Number of papers in 5 themes derived from examining papers

Data collection and combination

One of the key issues in DSM is the collection and combinations of data. It was also noted that satellite imagery and spectral indices are used as auxiliary data. Demattê et al. (2017) Depending on the season, soil class varies on the Normalized Difference Vegetation Index (NDVI) projection, due to its morphological and attributes configuration. In addition, hyper-temporal RS was highly effective in modeling soil texture. Efficacy of the hyper-temporal RS approach in predicting soil texture and coarse fragment classes was demonstrated in a semiarid region of the southwestern United States [3]. On the other hand, the efficient, accurate and low-cost use of hyper-depth spectral data for soil classification and soil mapping to optimize future soil surveys was demonstrated [4]. Rouze et al. (2017) conducted proximal gamma radiometric surveys within various landforms to determine to what extent aerial gamma radiometrics were reliably mapping soil properties on the ground. According to the study calcium carbonate equivalent can be mapped with both proximal and aerial gamma radiometrics within a uniform residuum [5].

The samples in the study region are very important for the accuracy of further results. Experiments conducted in China proved that SOM content maps predicted using representative training samples had generally higher accuracy than the results produced using non-representative samples, and comparative accuracies with the results produced using full training samples [6]. Grauer-Gray & Hartemink (2018) described and examined the raster method which characterizes soil profiles in two dimensions and can be used to quantify lateral variation and improve field delineation of soil horizons.

Several researches have addressed the problem of Digital Terrain Morphometry (DTM), which highly affects the results in DSM. The terrain attributes of a study area were decomposed using the wavelet analysis. Compared with standard DSM methods, most of the improvements in prediction accuracy in this study were slight or moderate in different situations [8]. The approach Nabiollahi et al. (2018) used in their study slopes with a large gradient and where land use was converted to agriculture were characterized by low values of SQIs (soil quality indices).

Methods and models

Much study in recent years well documented methods and models in DSM. As the study demonstrated the open digital mapping approach as a cost-effective, timely, and accurate methodology for peat thickness mapping and carbon stock assessment in the Bengkalis Island, Indonesia [10]. Furthermore, Open Source GIS, the results of Schmidt's fuzzy elements classification and r.geomorphon seem best suited at macro scale, whereas the TPI (Topographic position index) based landform classification performed best at meso scale [11]. Findings by Vermeulen & Van Niekerk (2017) suggest that the use of elevation data and its derivatives as input to geostatistics and ML holds much potential for monitoring salt accumulation in irrigated areas, particularly for simulating sub-surface conditions.

We obtained that according to the results described in the papers methods are divided into several parts as follows: Random Forest (RF), means of decision tree and Regression Kriging (RK). In case of Cyprus, maps derived with MLR had comparable prediction uncertainty and higher validation error than RF, indicating the better performance of the latter for DSM in topographical and pedological complex regions [13]. Moreover, for relatively flat terrain the use of RF algorithm and the freely available SRTM DEM combination for mapping the soils was highly recommended [14], while Keskin & Grunwald (2018) highlighted the strengths and weaknesses of RK studies and compared them with other pedometrical methods.

Beguin et al. (2017) showed the results of the research in Canadian boreal forest which proved that better mapping of soil properties may be achieved through quantitative assessment when selecting the statistical method and model specification (spatial vs non spatial models).

Mapping scale. In the majority of the tests the information about scaling in biological and chemical processes in soils is sparse [17]. In the whole soil texture variability tends to increase with depth across all scales up to depths of 60 cm. Beyond 60 cm the relationship becomes more complex [18]. Experiments carried out by Zhang et al. (2018) summarizes that using 1:50,000 soil map is an efficient way to reduce uncertainty in regional SOC simulations. Methodology about the spatial downscaling approach, particularly, which incorporates observational data, provides the facility for landholders or their consultants to exploit the availability of public digital soil mapping, and simultaneously incorporate their own (private) collected data for monitoring the soil resource at the farm scale [20].

Uncertainty assessment. Uncertainty assessment is the crucial part of DSM. From the result obtained in the case study, Vaysse & Lagacherie support the use of QRF (Quantile Regression Forest), rather than the use of RK (Regression Kriging), for deriving uncertainty estimates in Digital Soil Mapping studies with sparse soil observations for representing complex pedological cover that cover large spatial extent. The easiness, quickness and low cost in obtaining the magnetic susceptibility makes it to be the main alternative to the incorporation of spatial uncertainty in maps of mapping units.

Applications of DSM. Most frequent applications in DSM are soil organic carbon (SOC) (at different scale) and total nitrogen and predict their uncertainties. In this case, different methods are used. Mainly two different methods are used to assess the carbon stock. In the first case nine environmental variables as predictors were used to estimate the vertical distribution of SOC, soil total nitrogen, bulk density, and mapped their spatial distribution at five standard soil depth intervals [22]. And in the second case select appropriate preprocessing and methods to model SOC from Vis-NIR spectra. The quantification of SOC can improve soil-property information and supply digital soil mapping approaches to develop soil-property maps [23].

Conclusions

This review has sampled almost 289 issues in soil science from over 11 journals from the calendar years 2017 and 2018. The research generally divided quite readily into 5 themes which are addressed in turn. However, inevitably, a number of papers crossed theme boundaries and the author had to exercise judgment in these cases. The 'popularity' of the 5 chosen themes was indicated by classifying all the papers published in Geoderma, one of the leading journals. In most of the studies further investigations were required.

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LANDSCAPE STABILITY ANALYSIS MORPHOLOGY STRUCTURE OF LACUSTRINE THERMOKARST PLAINS WITH FLUVIAL EROSION IN AN ASYNCHRONOUS START SITUATION

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Abstract

One of the important questions, regarding the thermokarst development, is to find the principles of its distribution and dynamics with the purpose of forecasting environmental changes. Many researchers studied the thermokarst processes, but proper statistical methods regarding these are yet to be developed. In particular, the analysis of quantitative aspects of thermokarst lakes is to be considered. Various researches attempted to determine the age of thermokarst lakes, as well as the time of their occurrence.

The aim of the research is to analyze the complex landscape dynamics of thermokarst plains with fluvial erosion to assess the stability of its morphological pattern. Two opposite trends are facing within this landscape during the whole Anthropocene: the growth and, possibly, the emergence of new thermokarst lakes and the disappearance of thermokarst lakes due to the descent fluvial erosion.

The research results in the mathematical models of the dynamics of the morphological pattern of thermokarst plains with fluvial erosion for uniform natural environment, which were developed on the base of the mathematical morphology of landscape using the theory of random processes. The models are done: 1. for synchronous start of the thermokarst process; 2. for asynchronous start of the thermokarst process.

We performed the model approval for several study areas, which are located in different Arctic regions.

Key words: mathematical morphology of landscape, thermokarst lakes, fluvial erosion, remote sensing, cryolithozone

Introduction

Many researchers deal with the development of thermokarst lakes [1, 2, 3, 5] but only a few of them are devoted to the complicated development of thermokarst plains with fluvial erosion.

The thermokarst plains with fluvial erosion develop under two opposite processes changing the landscapes:

- appearing and increasing in size thermokarst lakes,
- drainage of the lakes by fluvial erosion and their turn into khasireis (drained thermokarst depressions)

This makes the analysis of the development and prediction of changes of thermokarst plains with fluvial erosion especially difficult. The use of mathematical morphology of landscape and remote sensing data can give interesting results for modeling the behavior of thermokarst plains with fluvial erosion and in terms of assessing the risk of damage by various engineering structures.

The goal of the report is describing an improved mathematical model of morphological pattern development for of thermokarst plains with fluvial erosion.

Materials and methods

The thermokarst plains with fluvial erosion are slight wavy subhorizontal areas covered by tundra vegetation, interspersed with lakes and khasyreis and rather rare fluvial erosion network (Fig.1).

The lakes are characterized with isometric and often round form. They are randomly spread within the plain. Khasyreis are flat depressions covered with meadow or bog vegetation. Similar to the lakes khasyreis are characterized with isometric form and random spreading within the area. The main parts of the region include: - flat tundra plain, - thermokarst lakes, - khasyreys, - fluvial erosion network.

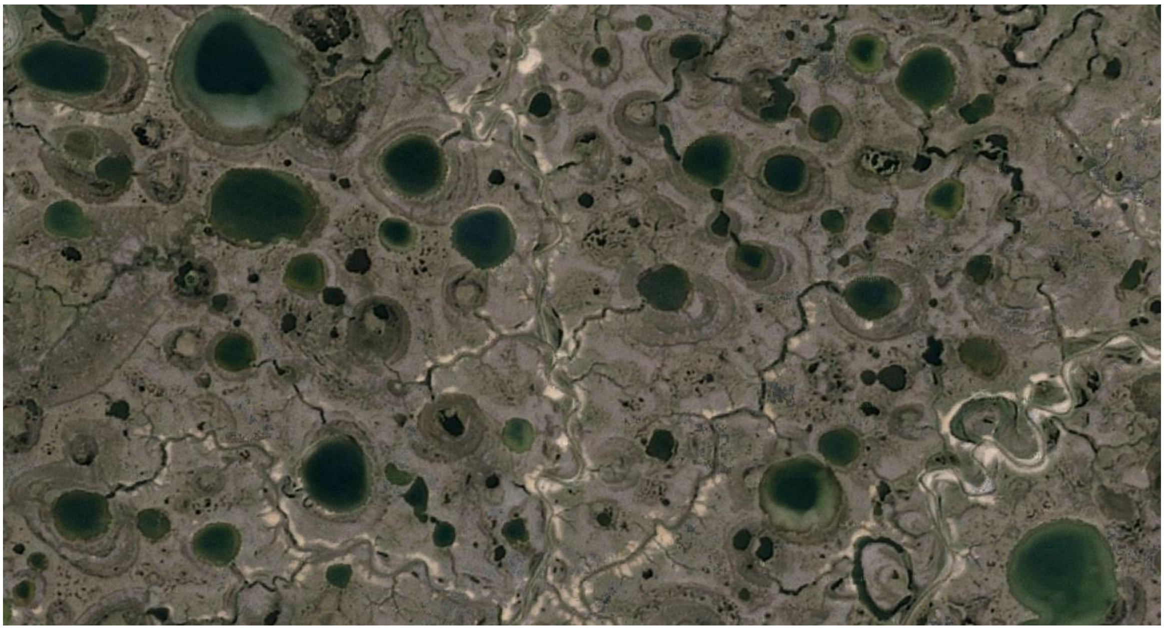

Fig.1. Typical view of the thermokarst plains with fluvial erosion on remote sensing data

We analyzed two variants of assumptions using mathematical models for areas with uniform natural environments. The models deal with the simplified case of climatic constancy. The models comes from an assumption that the size growth rate of the thermokarst lakes depends on random factors and proportional to the density of heat losses on the side surface of the lake. However, in one case we suggest a synchronous start of thermokarst processes (model 1.0), and in the other one an asynchronous start (model 1.1).

The model 1.0 has the following assumptions which we can conventionally call the basic ones:

1. Thermokarst depressions (germs of thermokarst lakes) were appearing within a relatively short period independently across the different non-adjacent sites.
2. The radius of an appeared thermokarst depression is a random variable; it is undependable of other lakes, and the growth rate is directly proportional to heat losses through the side surface of the lake basin.
3. In the course of its growth, a lake can turn into a khasyrei after draining by the erosion network; the probability of this does not depend on the development of other lakes; if it happens, the depression stops growing.
4. The appearances of new sources of fluvial erosion within a randomly selected area are random and independent events.

For the case of the synchronous start, the following initial dependencies obtained earlier in mathematical morphology of landscapes remain valid [4, 5].

- the radius distribution for free growing thermokarst lakes since time t after lake emergence (lognormal distribution):

$$f_0(x,t) = \frac{1}{\sqrt{2\pi}\sigma x\sqrt{t}} e^{-\frac{(\ln x - at)^2}{2\sigma^2 t}}, \quad (1)$$

where a, σ are distribution parameters, t is the time since the process has stated;

- the distance distribution from the center of the growing lake to the nearest sources of erosion structure (stream) which stops the lake growth and turn it into a khasyrei, obeys the Rayleigh distribution;

$$F(x) = 1 - e^{-\pi\gamma x^2},$$

where γ is an average density of the stream sources.

The mathematical analysis of the assumptions gives us the equations describing the development of the morphological patterns of the thermokarst plains with fluvial erosion for the given variant of the model [3].

They include the Poisson distributions for a number of either lakes or khasyreis within a random area, the exponential distribution of khasyrei areas after a long period of development of the landscape.

The radius distribution for the thermokarst lakes at any moment results from the radius distribution for a free growing lake but under the condition that the lake does not turn into a khasyrei; it means that the distance to a stream source is greater than the radius of the lake. Hence, the radius distribution density for the thermokarst lakes has the following expression:

$$f_l(x,t) = \frac{f_0(x,t)e^{-\pi\gamma x^2}}{\int\limits_0^{+\infty} f_0(u,t)e^{-\pi\gamma u^2}du}.$$

Substituting the expression for the free growth (1), simplifying and passing to the limit, we obtain the gamma-distribution of the lake area in case of the long period of landscape development:

$$f_{sl}(x,\infty) = \frac{\gamma^{\frac{a}{2\sigma^2}} x^{\frac{a}{2\sigma^2}-1} e^{-\gamma x}}{\Gamma\left(\frac{a}{2\sigma^2}\right)},$$

where $\Gamma(x)$ is a gamma-function.

The second variant of the model (1.1) differs from the basic one with the assumption of the asynchronous start. To be more precise, the first assumption changes: 1a. the emergence of initial thermokarst depressions (germs of thermokarst lakes) for non-intersecting time intervals and at non-intersecting sites are independent random events, and their probability depends only on the duration of the interval and the site size.

$$p_1 = \lambda \Delta s \Delta t + o(\Delta s \Delta t),$$

$$p_k = o(\Delta s \Delta t),\ k = 2,3...,$$

where λ is a parameter, k is a number of the depressions.

Besides, we get the fifth additional assumption:

5. The new lakes do not appear within the already existing lakes. Thus, the generation density of lakes becomes variable, since the surface free from the lakes changes.

The analysis of the model assumptions gives us essential conclusions about the process dynamics [3]. For example, we can get the radius distribution density for the lakes at time t; it is equal to the ratio of the number of lakes with a given radius, taking into account the different times of their occurrence and the probability of their non-transformation to khasyreis to the total number of lakes that have not yet turn into khasyreis. After simplification, it is equal to[1]:

$$f(x,t) = \frac{e^{-\pi\gamma x^2}\int\limits_0^t P_f(u) f_0(x,t-u)du}{\int\limits_0^t P_f(u)\int\limits_0^{+\infty} e^{-\pi\gamma x^2} f_0(x,t-u)dxdu}.$$

where $P_f(t)$ is a share of the area unoccupied by lakes at time *t*.

[1] We consider the distribution functions have the necessary qualities for a change in the order of integration (uniform convergence, uniformly integrable, etc.), and the random variables have finite moments up to the fourth order inclusive.

The distribution of the number of lakes will remain the Poisson one (since the probability of transition to a khasyrei does not depend on the location of the lake), but with a complex change of the parameter over time, the same applies to the khasyreis. After a long time, the distribution density of the thermokarst lakes approaches to a certain limit.
The analysis of the area development gives us the integral equation:

$$\ln P_f(t) = -\pi\lambda \int_0^t P_f(u) \int_0^{+\infty} x^2 e^{-\pi\gamma x^2} f_0(x, t-u)\,dx\,du$$

,
which solution is the function of the area free of lakes (“non-lake area”).

Using this equation in the case of the asynchronous start we find out the dynamic balance between the lake generation process and their transition to the khasyreis after a long time of the development. This dynamic balance may occur under very general condition, and it has some stable features, such as the limit distribution density of the lakes, the exponential distribution for the khasyrei area, the “integral-exponential distribution” for the lake area with the distribution density:

$$f_{sl}(x,\infty) = -\frac{1}{xEi(-\gamma\varepsilon)} e^{-\gamma x}, \quad x \geq \varepsilon,$$

where ε, γ are parameters, $Ei(-x) = \int_{-\infty}^{x} \frac{e^{-u}}{u} du$ is the integral-exponential function.

Thus, the mathematical analysis of the models gives the mathematical laws for the morphological patterns of the thermokarst plains with fluvial erosion for those variants (Tab. 1).

Table 1.

The distribution laws in case of the different models

Model	The distribution for lakes areas	The distribution of lake centers	The distribution of khasyrei centers	The distribution for khasyreis areas
Model 1.0	Gamma	Poisson	Poisson	Exponential
Model 1.1	Integral exponential			

Results and discussions

We performed the model approval for several study areas, which are located in different Arctic regions (Fig.2). The empirical testing of the models was done at different key sites (Yamal, Western Siberia, Kolyma).

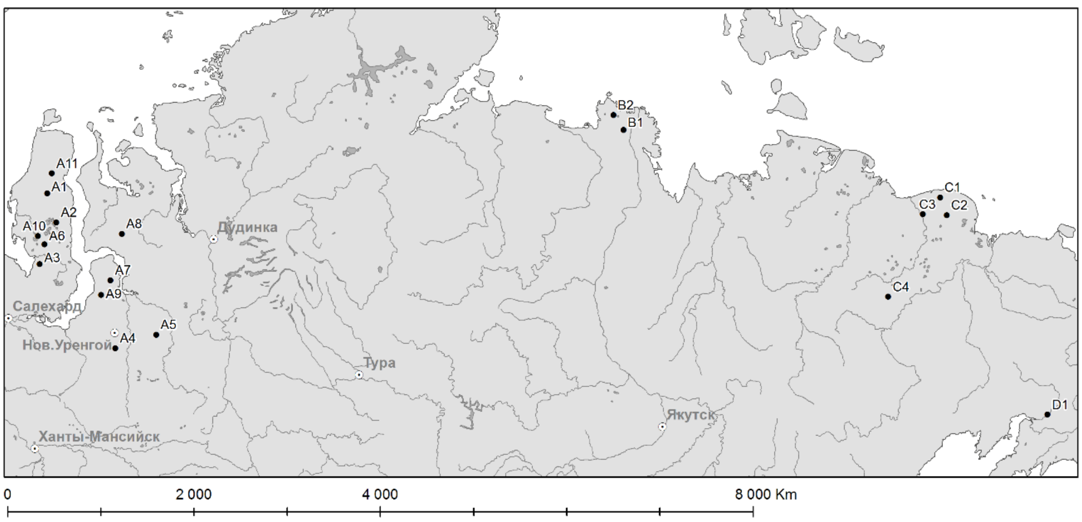

Fig. 2. An overview map of key sites.

We used remote sensing data of medium and high resolution. (Resurs-P, IKONOS, QuickBird, Worldview 2, Geoeye-1). We also used ArcGIS and QGIS for digitizing the contours of thermokarst lakes and khasyreis both automatically and manually. Statistical software with the Pearson criterion was chosen for testing the agreement between theoretical and empirical distributions.
Here are the following main results of the empirical testing of the models for the thermokarst plains with fluvial erosion.

The obtained data of the khasyrei areas include samples from 43 to 352 elements. The analysis shows that in 13 out of 17 samples from the different key sites the distribution of khasyrei areas corresponds to the exponential distribution at a significance level of 0.99 (Table 2). At the same time, 12 from these 13 samples demonstrates both the exponential and the lognormal distributions.

Table 2.

Correspondence between empirical and theoretical area distributions for khasyreis (a fragment)

Site number	Sample volume	p-value			
		Normal distribution	Lognormal distribution	Gamma distribution	Exponential distribution
A1	97	0.000	**0.766**	**0.127**	**0.179**
A2	62	0.000	**0.108**	0.000	0.000
A3	97	0.000	**0.670**	**0.221**	**0.539**
C3	176	0.000	**0.076**	**0.048**	**0.372**
D1	85	0.000	**0.661**	0.000	**0.225**

The empirical data about areas of the thermokarst lakes within the key sites at the thermokarst plains with fluvial erosion (Table 3) included samples from 49 to 2108 elements. In 9 out of 17 samples the distribution of lake areas corresponds to the integral exponential distribution and six of them demonstrate the agreement with the lognormal distribution. In 5 out of 17 samples the empirical distributions agree with both to the gamma and lognormal distributions that correspond to the model of the synchronous start.
The average radius distribution corresponds to the normal distribution only at one site; the same is true for the lake areas and the gamma distribution with the shape parameter equal to 0.5.

None of the tested distributions corresponds to 17% of the samples.

Table 3.

Correspondence between empirical and theoretical area distributions for the lake areas (a fragment)

Site number	Sample volume	Average (m^2)	p-value				chi-square	
							0.95	0.99
			Normal	Lognormal	Gamma	Exponential	Integral exponential	
A4	493	118059	0.000	0.000	0.000	0.003	50.676	18.475
A5	559	36798	0.000	0.000	0.000	0.000	**4.68**	6.635
A6	434	71626	0.000	0.000	0.000	0.000	**2.546**	11.341
A7	257	30130	0.000	**0.011**	0.005	0.000	**1.625**	9.21
B1	222	254272	0.000	**0.016**	0.000	0.000	**11.084**	13.277
C1	304	281956	0.000	**0.321**	0.000	0.000	**1.409**	6.635

We can thoroughly explain the correspondence of the empirical data to two different distributions including the lognormal one by two reason:

– The thermokarst plains with fluvial erosion at first developed as the lacustrine thermokarst plains because the probability of lake drainage was small as far as the initial lakes had a little size, while the areas of the lakes characterized with the lognormal distribution at the lacustrine thermokarst plains [4];

– The exponential distribution is a limit distribution at $t \to \infty$, while the time since the thermokarst process has started is albeit long, but finite.

Our research shows that the quantitative assessment of the natural hazard for lacustrine thermokarst plains should differ from that for thermokarst plains with fluvial erosion.

Conclusion

1. The mathematical models of the morphological pattern development for the thermokarst plains with fluvial erosion are substantiated; the mathematical morphology of landscapes is the basis of the suggested approaches.
2. General laws of the morphological pattern for the thermokarst plains with fluvial erosion in case of the uniform natural environment include Poisson distribution for the location of lakes and khasyreis and the exponential distribution for khasyrei areas.
3. Lake area distribution of the thermokarst plains with fluvial erosion is either “integral exponential” or gamma distribution, depending on different conditions.
4. The analysis of the obtained distributions leads us to the conclusion that the asynchronous start is widespread for the thermokarst plains with fluvial erosion. We can explain this by the greater liability (in comparison with the original surface) of khasyreis to the thermokarst and, therefore, the occurrence of the secondary thermokarst depressions inside the khasyreis.
5. The research shows that in case of the synchronous start these landscapes have a directional evolution, while the asynchronous start results in a stable state of the dynamic equilibrium and corresponds to the stable state of the landscape. This conclusion is important for prognostic issues due to climate change.
6. The developed models can be the base for the impact probability assessment of an engineering construction by thermokarst.

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COMPLEX STUDY OF THE NATURE OF THE CAUCASUS (ON MATERIALS OF THE ACADEMIC "PHYSICAL" EXPEDITIONS OF XVIII CENTURY)

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Abstract

The work is devoted to the historical aspects of the development of geographical research of the Caucasus. The basis for the performance of the work lay down the materials of the XVIII-XX centuries, including archive materials. The main goal of the work is aimed to the compilation and systematization of geographical information about the Caucasus and there analysis. It is shown that the academic "physical" expeditions were the beginning of the complex development of the nature and the population, and also served as the basis for the scientific study of the Caucasus. The latest results on the nature and economy of the Caucasus, as well as other regions of the Russian Empire, contributed to the country's transition to a new level of economic and economic development. It is noted that new information about the nature of Ciscaucasia enriched science, contributed to the development of a number of scientific fields and still have scientific value.

Key words: Caucasus, academic “physical” expeditions, XVIII century, nature, population, geographical researches

Introduction

In the history of geographical researches of the Caucasus a bright page is the activity of academic expeditions of the second half of the XVIII century. The idea of organizing and conducting expeditionary research in the Russian Empire belonged to M.V. Lomonosov (1711-1765), who having received a brilliant education in Europe, wanted to see Russia equally enlightened and developed.

It was assumed that the development of expeditionary activity will provide a comprehensive study of the poorly studied territories of the Russian Empire and a synthesis of information about its nature and population.

Until the beginning Prior to the second half of the XVIII century about the Caucasus, as well as about a most part of the Russia, there was only scattered information that gave fragmentary ideas about nature. The different natural conditions of the Caucasus, the multinational composition of the population, the processes of cultural and economic interaction between the peoples of the Caucasus – this is not the whole list of interests that were the subject of research in different historical epochs. An important stage in the study of the unstudied areas of the Caucasus was the XVIII century, when the Russian State put before the Academy of Sciences the task of performing a socio-political order related to the study of the natural wealth of Russia, especially its north-eastern and southern territories.

The activities of academic expeditions to study the nature of the Caucasus are covered in numerous literary and archive sources.

Main part

In 1768-1774 The Imperial Academy of Sciences sent five expedition teams: three from Orenburg (under the leadership of P.P. Pallas (1741-1811), I.I. Lepekhin (1740-1802), I.P. Falk (1727-1774), two – to Astrakhan (under the leadership of S.G. Gmelin (1744-1774) and I.A. Güldenstädt (1745-1781).

The expeditions were set to collect information for the “benefit of the common state and the spread of science” [1]. Large-scale programs and unified instructions were developed for expeditions. Particular attention was paid to the fact that "from natural and other memorable things in all months There is nothing important about it and you can find out about what was left or viewed ”[1].

To cover a wide range of researches on the nature and population of the Caucasus, expeditions were instructed to collect information about destroyed monuments, ruins, barrows, graves, tools and other material evidence that can be attributed to archaeological monuments. It was also noted that “investigations and observations of traveling travelers from nature should concern in general to the following subjects; but exactly:
1) to the nature of the earths and waters; 2) to each unprocessed land or unpopulated place”[2].
Noting the socio-political significance of the expeditions, M.A. Polievktov (1935) in his work writes: "Expedition 1768-1774 of the Academy of Sciences, serving the economic interests and the aspirations of the nobility of feudal Russia of the second half of the XVIIIth century ... and examined the entire southeast of European Russia and a number of adjacent areas its two participants, Gmelin and Güldenstädt, captured the entire Caucasus” [3, p. 123].

An expeditionary detachment I.A. Güldenstädt and S.G. Gmelin was one of the first to be sent to the Caucasus (Astrakhan academic expedition of 1768-1774). Young I.A. Güldenstädt was instructed to examine the vast territories of the south-east of the European part of Russia. Caucasus route I.A. Güldenstädt ran through Kizlyar, Kabarda, Ossetia, Georgia [3, 4, etc.]. He was entrusted with "... a survey of those areas of the Caucasus in which in the XVI-XVII centuries. The Moscow State produced repeated and thorough intelligence ... but which were not captured by the 13th century Russian Caucasus studies, which were aimed, in accordance with the objectives of the Russian aggressive policy of the time, mainly on the Caspian regions of the Caucasus ”[3, p. 123]. There are detailed descriptions of the Güldenstädt route, which was accompanied by a collection of detailed geographic information about the localities: “The path of the Güldenstädt expedition went to Novgorod, Porkhov, Old Russa, Ostashkov, Rzhev, Mozhaisk, Moscow, Tula, Yelets, Voronezh, Tsaritsyn and Astrakhan, where the expedition arrived 4 December 1769. From Astrakhan Güldenstädt and his companions on January 13, 1770 moved to Kizlyar, where he arrived on January 23 and from where he traveled the nearest region of the Caucasus along the river. Cambilya, Sunzhe, Aksay and Koisu, examining, among other things, local oil births and mineral springs ... ”[3, p. 124; 7, 8].

Complex studies of the route of the expedition of Güldenstädt (1768-1775) are of great value from a scientific point of view, because thanks to them a wealth of factual material was collected. Numerous reports, diaries and cartographic materials I.A. Güldenstädt is currently stored in the St. Petersburg branch of the Archive of the Russian Academy of Sciences (SPbB ARAS) [3] and published in a number of papers, and also available in the archives of the Russian Academy of Sciences [4–9, etc.]. I.A. Güldenstädt not only fulfilled the program set before the detachment, but also went far beyond its limits. His travel notes formed the basis of the famous two-volume work "Reisen durch Russland und im Caucasischen Geburge" (1787-1791) - "... a detailed, detailed and highly conscientious description of his entire journey, ..." [3, p. 125]. This work was highly appreciated by the scientific community: “... For the Caucasus, mainly Northern and Reisen Georgia, Güldenstädt is a capital work, which until that time was not yet in Russian or in Western European Caucasus literature. It covers all aspects of natural science (especially botany and zoology), provides information on local productive activities (agriculture, silkworm breeding, mining, oil, manufacturing, etc.) and trade; on ethnography and history of the region; dictionaries of Georgian, Mingrelian, Svan, Circassian, Chechen and other languages and the adverb of the Caucasus are given .. ”[3, p. 125]. Güldenstädt’s detailed information about the geographical location of the Caucasus Mountains and their general natural conditions, on the river The Terek, its tributaries, Caucasian villages and peoples (statistical data on the number, customs, customs, religion, etc.), industry and the economy, etc. have not yet lost their scientific significance. This was written by K. German (1809) in the preface to the Geographical and Statistical Description of Georgia and the Caucasus: “Mr. Güldenstädt’s journey through Russia and the Caucasus Mountains contains such precious Geographic and Statistical news about Georgia and the Caucasus, which are not brought us none of the newest travelers ... "[7].

Expedition route S.G. Gmelin across the North Caucasus passed through Astrakhan, the Terek estuary, Derbent and Baku, the coastal part of the Caspian Sea. He visited Shamakhi, Salyan, reached Iran. From 1771-1773 he explored the entire coast of the Caspian Sea [3]. In the task of research S.G. Gmelin included a survey of the Caspian oblasts, which was carried out in 1769-1774 in several stages. Detachment S.-G. Gmelin began his journey from Astrakhan, covered "... the northeastern Ciscaucasia, the western and eastern shores of the Caspian Sea ..." [3, p. 116]. The tasks of the research included "... a survey of those areas of the Caucasus, which, due to their great economic and political significance, have long attracted the attention of Western European and Russian travelers to Caucasus studies ..." [3, p. 116]. It was noted that the program developed by the Academy of Sciences for Gmelin was rather broad. Gmelin's research results formed the basis of his five-volume description of his journey. Were obtained rich and detailed information on natural history, detailed ethnographic descriptions of various ethnic groups of the Northern Ciscaucasia. Gmelin gives a detailed description of Astrakhan and Astrakhan Territory, individual localities and cities: Mozdok, Kizlyar, Derbent; information about the flora, fauna, political relations of the time, the history of the region, historical monuments [3, p. 116]. Descriptions are accompanied by illustrations, maps. The handwritten and other materials of the expedition Gmelin are in the St. Petersburg Branch of the Archive of the Russian Academy of Sciences [10-12].

Much has been done in the field of geography, geology, paleontology, botany, history, archeology, economics, and philology of P.S. Pallas. An important role in expeditionary research was played by an expedition led by P.-S. Pallas. About the expeditions of 1768-1774, the following was noted: “Having to examine all areas of the“ Russian Empire ”, this expedition, which was divided into a number of individual expeditionary parties, due to such a socio-political order, focused its attention on the south-eastern sector of European Russia and adjacent to it, the Urals, the Caspian region, the Caucasus and part of the Black Sea. The participation of Pallas in the expeditions of 1768-1774 differed only in the partial attitude of these expeditions towards Ciscaucasia (the North Caucasus). A significant contribution to the study of this part of the Caucasus was made already in the second expedition (1793-1794 (to the Astrakhan region) [3, p. 156].

Throughout the journey, Pallas kept detailed travel records. The factual material he collected became the basis of his famous work "Journey to different places of the Russian state ", which remained a reference book for many generations of scientists. In the preface to his work, Pallas speaks about authenticity as the main feature of travel description. Thanks to the factual evidence of PS Pallas and l able to raise the level of knowledge in various scientific fields.

He was engaged in the study of water, soil, farming, the spread of diseases and methods of their treatment, the study of beekeeping, sericulture, and cattle breeding. He studied the mineral wealth and mineral waters, drew attention to the arts, crafts, crafts in the provinces, which deals with the population, etc.

P.-S. Pallas collected all sorts of information about the manners, customs and beliefs of the peoples, including the North Caucasus [3]. P.S. Pallas carried out the general management of the scientific expedition I.A. Güldenstädt. After his tragic death in 1781, P.S. Pallas took the responsibility to complete the work he had begun. Three years P.S. Pallas worked on his manuscripts and diaries. The result of this work was the book “Journey to Russia and the Caucasus Mountains (1787-1791) (I.A. Güldenstädt), published in Germany in German and translated into Russian in 2002 [8]. The archives of the RAS contain materials on the activities of P. Pallas during the study of the territory of Cis caucasia [13-15]. Caucasian route I.P. Falk (1768-1775) passed through Astrakhan and Kizlyar. He investigated the Terek greenhouses and Kizlyar waters (Lomonosov, 2011). About him in the domestic and foreign historical literature there is not much information, not found as a portrait image. During the trip to the Russian Empire, he, like other members of the expeditions, collected a lot of factual materials that are in the St. Petersburg branch of Archive of the Russian Academy of Sciences [16].

The years were spent processing Falk handwriting materials. The difficulties of translation were that the recordings were made in three languages. Much attention was paid by Falk to the flora of the territories along which the expedition route passed. Research I.P. Falk was characterized by the fact that he tried to make the most accurate descriptions of nature (plants, animals), life and employment of the population. Many entries were made in three foreign languages. On the processing of materials I.-P. Falk took many years. The results of the expedition are available in the archives of the Russian Academy of Sciences and other sources [16, 17].

Conclusion

Despite the fact that the activities of academic expeditions of the XVIIIth century was covered by many scientists and there was devoted a lot of work, there were many unexplained issues and unrecognized and untranslated manuscripts. Based on the conducted research, we can made the following main conclusions:

- extensive factual material about the nature and population of Ciscaucasia was collected and systematized; the peculiarity and scientific value of the geographical information about the territory was that many of them were obtained for the first time and not just from ordinary travelers who want to satisfy the narrow-minded curiosity, but from scientists who have theoretical and practical experience;

- drawings, descriptions, plans and drawings of archaeological monuments were composed, which was the part of the geographical description of the studied territories of the Russian Empire; materials from expeditions to study the natural resources of the area caused particular interest;
- cartographic information about the territory and built new maps were updated;
- the activity of academic ("physical") expeditions laid the foundation for the development of scientific disciplines and studies about Caucasus;
- academic expeditions of the XVIIIth century. opened the era of the complex geographical research.

Thanks to academic expeditions, geographical information about the poorly explored territories of the Caucasus was enriched. The results of the expeditions influenced Russia's socio-economic and political status. The results of the expeditions are reflected in the scientific literature and cartographic materials about the Caucasus, including in the works of the authors [18–23] and still remain relevant.

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SOME ISSUES OF SPATIAL IDENTIFICATION, ALLOCATION AND MAPPING OF CULTURAL NATURAL-TERRITORIAL COMPLEXES (CASE STUDI OF FOOTHILLS' LANDSCAPES OF THE SAGURAMO-IALON RANGE)

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Abstract

On the basis of the European Landscape Convention of the Council of Europe, the landscape became one of the most important key research objects into geographic scientific research. UNESCO's World Heritage Convention as of 1992 and European Landscape Convention of the Council of Europeas of 2000 discusses the concept of "landscape" and "cultural landscape" as " an area perceived by people ", the common creature of nature and human ". The new approach is dramatically different from the traditional approach, and many scientists have recently shared it. Therefore, a new approach is to be developed for landscape mapping.

We believe that the legend of landscape-cultural map should reflect the landscape organization as a process, the outcome of assimilation and conceptualization of the territory by that or this culture(s) including both as modern and hereditary features. By doing so it coincides with differentiation of natural units of the territory but not by its copying.

The report refers to the peculiarities of Spatial Identification, Allocation and mapping of cultural natural-territorial complexes and in the case of foothills' landscapes of Saguramo-Ialno mountain range, based on the mentioned conventions and the experience of professors N. Beruchashvili and the famous scientists.

Key words: Cultural landscape, Landscape Convention, natural-territorial complexes

Introduction

On the basis of the European Landscape Convention of the Council of Europe, the landscape became one of the most important key research objects into scientific research in 2000. According to this Convention, "Landscape" is an area perceived by people the nature of which is the result of impact and interaction of natural and/or social factors [1].

According to this definition, the European Landscape Convention of the Council of Europepresented a real picture existed in science. The landscape is an object of keen interest in different fields of science and arts: in aesthetics, architecture, painting, poetry, history, even psychology. Out of this, the landscape exhibits the intrinsic marks and is interpreted in different manifestations of culture. However, historically it was developed so, that the deep and multifaceted understanding of the concept of landscape took place in geography, mainly in physic one, and in recent years in behavior and culture [2] ones.

Against the background of the Council of Europe's Landscape Convention, Professor M. Grodzynski (2005) gives us a more unifying representation of different definitions of landscape's concept, he interprets the landscape as a general cultural concept: the landscape - this is the space that is shaped by the configuration of the place, which is occupied and changed by its own elements.

Sharing the values of the European Landscape Convention, Prof. Grodzynski's opinion and the scientific experience of Prof. N. Beruchashvili's School, we think, that as the general cultural concept, the landscape is the homogeneous space, perceived by human, containing some components, the shape of which is formed by the configuration of the territory, and its nature is a result of interaction and interaction of the natural and/or social factors.

Currently, with the understanding of "Landscape", the concept of "cultural landscape" has also obtained the unusual popularity that has been introduced in the scientific application by A. Humboldt, O. Schutter, K. Zauer and B. Semionov-Tian-Chanski in the beginning of XX century [7].

The UNESCO World Heritage Convention 1992 examines the concept of "cultural landscape" as "the common creature of nature and human". An interesting and acceptable interpretation of the concept of "cultural landscape" seen in this extent has been provided by Professor M. Grodzynski.

He says: cultural landscape is the type of space that has been assimilated spiritually and materially by a certain carrier of culture and its territory's importance and configuration is attached at the level of collective consciousness and subconscious [2]. The contemporary performance of the "cultural landscape", which combines interesting, different definitions, has been provided by Professor T. Krasovskaya. According to Professor T. Krasovskaya, "cultural landscape" is the natural complex, which has been transformed and used by a human as a result of permanent interaction of human for clear acceptance of material, ecological and spiritual values [6].

Materials and methods

New approach is dramatically different from traditional approaches. Therefore, many things in landscape science and research are to be reevaluated, a new vision is to be developed.

Until now, there is no hierarchy of cultural landscapes that would allow us to establish their ranking, but their polyscaling, anisotropy, polarization and other properties are already quite well defined (4,5).

Discussion

Establishing the representations on cultural landscapes provides the need for their spatial identification - the establishment of a spatial hierarchy, i.e. the development of ranking that is organically characteristic for every geographical discipline. Also, the question arises – what is the difference between "cultural-landscape" and "natural-landscape" unit? The legend of the cultural-landscape map should reflect the landscape organization as a process, the outcome of the assimilation and the comprehension of the territory by some culture (cultures) including both contemporary and hereditary features. By doing so it coincides with differentiation of natural units of the territory but not by copying it (3).

According to T. Isachenko and G. Isachenko (2017), allocating the complex cultural-landscape units is to be essentially based on structural values which are visually visible in modern landscapes and/or objectively determined by topographic and thematic maps and remote imagery. Cultural-landscape units, as reflection of some condition of the landscapes, are less sustainable compared to the "base" units of physical-geographical zones that are allocated by homogeneity of the geological structure, relief, climate moisture regime and others.

We think, approach of zoning the cultural landscapes and allocation of their borders proposed by T. Isachenko and G. Isachenko with some changes proposed by us, should be based on the following grounds:

1. The principle of landscape homogeneity, natural peculiarities (relief and geological structure, surface sediments composition, surface waters, etc.), those impacting on natural management and the landscape structure of the territory (including measures, arrangement of agricultural crops, resettlement peculiarities, buildings, configuration of roads etc.) in the different phases of history, should be accounted and taken into consideration while allocating cultural landscape units.
2. The allocation of cultural landscapes must be based primarily on the material features of territory's assimilation (reclaiming) - as inherited from previous epochs, as well as on modern ones.
3. The type of natural management (including hereditary), not preconditioned by the natural conditions of the territory, but by combination of other factors (changing the state boundaries, the economic-geographic location, the change of ethnicities, the growth of cities, enhancement of their influence zone, etc.) should be equally accounted.
4. The modern state of cultural landscapes is considered as the interaction of natural landscapes and the assimilation of the territory at different historical stages: the cultural landscape is "the Union of Times" or the palimpsest [8].
5. Cultural landscape units should equally reflect the outcome of deliberate actions and natural processes in cultural landscapes (including, for example, the influence provided by the village or city).
6. Spatial polyscaling of the processes of territory's assimilation, related to various socio-economic processes, stipulates the polyscaling of allocated cultural landscapes.
7. The peculiarities of intangible culture related to the ethnic and confessional composition of the population (language dialect, folklore, link with certain confessions, local toponymics, etc.) are considered as the derivative of cultural landscapes ("forming element") and in allocating the units can be used as indicator signs – "markers" in the transformation of landscapes by some culture.

8. Apart from this, so called associative cultural landscapes [10] – for example places, related to prominent persons, historical battles, etc. may be used as additional indicators in allocation of cultural landscape units.

9. As in modern times, urbanization and related recreations become the leading factor of space assimilation (what importantly supersedes the agricultural use) their role in the formation of cultural landscapes increases immensely. Urbanized areas become the core of modern cultural-landscape differentiation. Large villages, cities, and their direct influence zones are considered as some cultural landscape units.

10. The boundaries of cultural-landscape units depend on the degree of natural non-homogeneity of the territory as far as it has influenced and influences the nature of natural management. If different natural landscapes are assimilated in the same way, then they can be combined into one cultural landscape. Consequently, the landscape distinctive with uniform nature, in case of realization of different models of natural management is differentiated as different cultural landscapes.

11. As cultural-landscape units' borders have different originality (natural, ethnic, political, socioeconomic, etc.), in setting them the "floating indicator" method is applied [11].

12. Dynamism of cultural landscapes determines the sharp time partiality of the map legend and they are to be constantly updated.

Some changes proposed by us are related to the introduction of the principle of landscape homogeneity, to the transition advantages of the material features of natural peculiarities and territory assimilation (reclaiming), to the size of the study area.

Conclusion

On the above-mentioned basis, the above described approach should be used not only for the large region, such as the Leningrad region's zoning, but also for the creation of a cultural-landscape map of different size regions, for spatial identification, hierarchy determination and allocation of differential rank (from Landscape to Facies) natural-cultural complexes.

We believe that considering the material characteristics of reclaiming and natural features should be taken into consideration in mapping the cultural natural-territorial complexes applying by transition advantage of the "floating indicator" method.

Taking into consideration the approach of T. Isachenko and G. Isachenko (2017) mapping the cultural natural-territorial complexes of the foothills' landscapes of Saguramo - Yalno Range and allocation of cultural landscape units is based on complex features, including, first of all the following is accounted and taken into consideration: 1. The principle of homogeneity of the landscape units , 2. The size of the territory and the rank of the landscape units, 3. The natural features (relief and geological structure, soil structure, surface water, etc.), 4. Material characteristics of assimilation of the territory (reclaiming); Unity of the factors preconditioning the type of natural management in time extent, including the rural influence as a cultural-landscape differentiation's core. 5. Due to the dynamism of cultural landscapes, the map legend is biased and constantly updated.

Allocating the boundaries of cultural natural-territorial complexes of the foothills' landscapes of Saguramo - Ialno Range depends on the degree of natural non-homogeneity of the territory so far as it has influenced and influences on the nature of natural management. If different natural-territorial complexes are assimilated in the same way, then they can be combined into one cultural natural-territorial complex. Consequently, the natural-territorial complex distinguished with a uniform naturalness is differentiated as different cultural complex in the case of realization of different models of natural management.

As the boundaries of cultural natural-territorial complexes have different originality (natural, ethnic, political, socioeconomic, etc.), in setting them the "floating indicator" method is applied [11], which we call the method of transitional advantage.

On this basis, we apply the approach of mapping the cultural natural-territorial complexes of the foothills' landscapes of Saguramo - Ialno Range for the smaller territories (at the level of facieses). It can also be successfully used to create a cultural-landscape map of different size regions, for spatial identification of the natural-cultural complexes of different ranking (from landscape to facieses), to determine hierarchy and allocation.

The report discusses the peculiarities of mapping of cultural natural-territorial complexes based upon the mentioned approach for foothills' landscapes of Saguramo - Ialno Range (for surrounding of the former

Martkopi geographical observation station). Also, we have made a comparative analysis of the new map drawn up by us with the map of the natural-territorial complexes of the Martkopi physical-geographical observation station's area that are based on the ancient and traditional basis.

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SESSION 2. HUMAN GEOGRAPHY

TERRITORIAL FRAGMENTATION, NEWLY EMERGED BARRIERS AND "BORDERSCAPES" IN THE POST-SOVIET SOUTH CAUCASUS

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Abstract
South Caucasus is a landbridge between the Black and Caspian Seas and a geoeconomic crossroad for the trade of goods and hydrocarbons along the East-West route. At the same time, it is considered a region "at risk", because of the ethnic conflicts occurred after the collapse of the Soviet Union, that led to the establishment of self-proclaimed Republics backed by Moscow. Furthermore, the lack of economic and political integration among the States of the region has produced a territorial fragmentation that can be observed in a multilayered conflictuality (among States, among States and breakaway entities, among regional organisations, among geopolitical orientations) and in a process of (re)borderisation, which is made visible and tangible by means of military barriers and "iron curtains" along instable ceasefire lines and *de facto* borders. The paper aims at analysing the difficult regional "borderscapes" and their territorial repercussions, in the context of the ongoing geopolitical and geoeconomic dynamics.

Key words: South Caucasus, territorial fragmentation, ethnic conflicts, breakaway entities, borderscapes.

Introduction

An area of transition between East and West and a landbridge between the Black Sea and the Caspian Sea, today the South Caucasus (SC) is divided, after the collapse of the Soviet Union, into three independent States: Armenia, Azerbaijan and Georgia. The ethnic mosaic of the SC is most intricate: ethnolinguistic groups belonging to the Caucasian, Indo-European and Altaic families inhabit the region following a territorial distribution that rarely matches borders, while Christianity, particularly Orthodoxy and Gregorianism, and Islam, predominantly Shiite, coexist in a condition of latent conflict.

The SC is considered a strategic area and a geoeconomic crossroads for the trade of goods and hydrocarbons on the East-West route, as well as a geopolitical "fault" and a region "at risk" [1] because of the instability linked to the ethnic conflicts that broke out after the collapse of the Soviet Union, which led to self-proclaimed Republics backed by Moscow and to the emergence of strategic-military barriers along unstable cease-fire lines.

The situation of the borders, drastically modified in 1991 by the dissolution of the USSR, has since undergone further, dramatic distortions after the ethnic conflicts that involved the three SC States, deeply transforming their territorial composition and demographic structure, hindering their normal functioning and transition to the rule of law and conditioning their sovereignty, today greatly limited both by breakaway entities and the Russian presence, which exerts a military, economic and cultural influence on the region that is very difficult to escape. The old barriers dictated by the Cold War have been replaced by others, less stable and predictable, and, in a way, even more impenetrable.

Thus the aim of the paper is to take stock of the region's shifting and unstable *borderscapes*, in view of the ongoing geopolitical and geoeconomic dynamics.

Materials and methods

The analysis was conducted on the basis of the scientific literature elaborated by political geographers, political scientists and contemporary historians, as well as practitioners, officers of governmental and

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supernational organisations, research institutes and *think tanks*, with particular reference to issues relating to energetic sources in the Caspian Sea and their transportation, Eurasian trade routes, armed secessions and the subsequent creation of *de facto* independent political entities, border dynamics and their territorial settlement.

Furthermore, numerous field missions have been carried out between 2010 and 2017, most of which under the academic agreement between Tbilisi State University (Georgia) and "G. D'Annunzio" University of Chieti-Pescara (Italy).

The geoeconomic and geopolitical context

The SC in the Eurasian scenario

Since the Nineties, the SC has shifted from being a peripheral area of an "imperial" structure (first czarist, then soviet) to being the *landbridge* between the Black Sea and the Caspian Sea, between post-soviet space and European Union, between East and West: in fact it represents a valid option for trades along the East-West route, especially the transportation of hydrocarbons extracted from the Caspian fields (Fig. 1). The Caspian region, and in particular the Absheron peninsula where Baku is located, has, in fact, an old heritage in oil mining. However, the Soviet Union did not have the technology necessary to deeply exploit the underwater oilfields. Moreover, because the oil resources from Siberia and the Volga region lended themselves to a much cheaper exploitation, the Caspian resources were not a priority.

All of this has changed with the dissolution of the Soviet Union: as soon as Azerbaijan, Kazakhstan and Turkmenistan - which, along with Russia and Iran, overlook the Caspian Sea - reached independence, hydrocarbons became strategically crucial. For their part, international oil companies and the main powers immediately showed a keen interest in entering this new market, giving birth to what has been defined the contemporary reissue of the nineteenth century's "Great Game". This is not the place to discuss such a complex matter. Suffice is to say that the conflicting views - the western one and the Russian one - from back then, today appear to be quite balanced, even though in a first phase everything seemed to indicate that the first one would eventually prevail on the second, given the western block's economic and technological superiority. This, however, was an underestimation of the neo-imperialist ambitions of Putin's Russia, its regional influence and its ability to direct, by hook or by crook, the local actors' choices. Not to mention the strategic interests of some western countries (Italy and Germany, for instance) and especially China, today more and more present and active in the area.

The transportation of hydrocarbons, however, is not the only reason of interest towards the SC: the region would have attracted the international attention anyway because it represents one of the possible routes, and probably one of the cheapest, for trade between the Far East and Europe, that is expected to expand greatly. The first to underline the geoeconomic and geopolitical importance of a transportation route in Eurasia, in view of a general reimagining of the relationship between East and West dictated by the imminent end of the Cold War, was in September of 1990 the then Foreign Minister of the USSR Eduard Shevardnadze. Since that moment the idea began to take form internationally, especially under the impulse of the new geopolitical and geoeconomic conditions that were forming after the fall of the Soviet Union, which made such an option economically enticing and politically viable.

On the base of this strategic view the TRACECA project, acronym of "*Transport Corridor Europe Caucasus Asia*", was born, an EU program aimed at the restoration and adaptation to the European standards of the road, rail and port infrastructures of the new independent SC and Central Asia States (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) and, subsequently, Bulgaria, Iran, Moldova, Romania and Ukraine. TRACECA also fits in the broader picture of the international project already known as "New Silk Road", and more recently as "*One Belt One Road"* (OBOR). Strongly supported by China, this route will connect - and, to some degree, already connects - the main European and Asian terminals via an infrastructural web without interruptions or bottlenecks. The SC fits in this scenario, although to a lesser extent than in its original formulation (which, unlike today, excluded any and all transit in Russian and Iranian territory). In this regard, we must mention the completion of the Baku-Tbilisi-Kars trail, which organically fits the OBOR, representing an important land segment of the project.

It should be noted, however, that a "regional" tout court approach to the geopolitical and geoeconomic analysis of the SC risks being misleading or wrong [2]. As we will see later, the three Countries mainly follow alternative directions, which in some cases turn out to be incompatible.

Fig. 1. The South Caucasus pipelines
[Source: Heritage Foundation]

The situation is well exemplified, for instance, by Armenia [3], which, at the moment, is cut out of the aforementioned East-West trades, for reasons that will be made clear later. On the other hand, Armenia is present, although as a crossing territory, in an alternative trade route, which could be defined as a North-South route regarding basically the exchanges between Russia and Iran. Thus the geoeconomic scenario in which the SC is immersed turns out to be extremely complex, and the term "crossroads", also sometimes used to define the SC, appears as fitting as "landbridge".

"*No peace no war*": the unsettled conflicts in the SC

The origins of the conflicts involving the SC since the Eighties are due to the soviet *divide et impera* policy, consisting in the territorial division of the various national groups in order to weaken them and make them dependent on Moscow. When the USSR collapsed, national belonging became the answer to a need of identity generated by the empty space left by its disappearance. At the same time, it became possible for new political currents to emerge without fear of repression. Liberal and democratic ideologies were developing, but only among the intelligentsia, while nationalism took the place of communism as the dominant ideology. In the Caucasus, considering the complexity of the ethnic context, nationalisms developed unrestrained and encouraged the use of weapons. Here again, an exhaustive examination of the genesis and dynamics of the conflicts would exceed the purpose of this paper. Therefore, only brief mentions will be made, so as to gain an overall updated impression of the situations that have emerged on the field (Fig. 2).

Nagorno Karabakh (NK), an already autonomous province (*oblast*) with an Armenian ethnic majority within the Azerbaijan Soviet Socialist Republic (SSR), proclaimed its independency after the dissolution of the Soviet Union [4, 5, 6]. Between 1991 and 1994 the NK was home to a bitter conflict (around 20.000 victims and over a million IDPs) between Azerbaijan and the Armenian secessionists supported by Armenia and Russia, which established its *de facto* independence. Outside NK territory, the secessionists also occupy some areas on the border with Armenia, which would be returned entirely or partially to Azerbaijan in case of resolution of the conflict. Since May, 1994 an armistice has been in force and a difficult peace process is under way, under the aegis of the OSCE. The negotiations are stalling since 2009, while in April of 2016 there was a particularly intense escalation along the "cease-fire" line, with tens of casualties even among civilians, according to reports from Azerbaijani sources. Finally, it should be reported that in February, 2017 a referendum was held to modify the name of the breakaway entity in “Republic of Artsakh”, historic Armenian toponym of the region.

During the Soviet period, Abkhazia and South Ossetia, both bordering Russia, had the status of autonomous Republic and autonomous*oblast*, respectively, within the Georgian SSR. In 1991 the two regions proved to be hostile towards Tbilisi proclaiming their own independence and giving birth, with Russia’s support, to armed secessions which secured their *de facto* independence (since 1992 for South Ossetia, since 1993 for Abkhazia). A particularly serious resurgence of the conflict for South Ossetia took place on the occasion of the Russian-Georgian war of August, 2008, also called the “five-day” war (8-12 August, 2008). There is no agreement about the causes that sparked the “five-day” war with Russian military aggression on Georgia’s territory, but it is certain that it caused a reinforcement of the separatism and a fortification of the Russian presence within the SC, which would suggest the hypothesis of a strategic plan by Moscow. Furthermore, as a result of the conflict, Russia and a few more States[2] officially recognize the independence of the two breakaway entities.

Fig. 2. The unsettled conflicts in the South Caucasus
[Source: N. Beroutchachvili, J. Radvany. Atlas geopolitique informatique du Caucase. Paris, 2009]

Caucasian conflicts have similar characteristics: although numerically much smaller, the separatist minorities have managed to achieve military victories and establish a *de facto* independence [7, 8, 9]. As already stated, such victories have been achieved thanks to Russia’s military support in the first place, but Armenia’s intervention in the NK conflict has been crucial. The consequences are similar, too: besides economic and human disasters, the conflicts have seriously damaged the political context of the States involved. The situation of conflict, in fact, represents an obstacle to the development of democratic life, as well as an excuse for the reinforcement of authoritarian policies in the name of internal security and stability. Furthermore, there is, in the cases of Georgia and Azerbaijan, the presence of hundreds of thousands of IDPs (internally displaced persons) expelled from the regions controlled by secessionists. In conclusion, none of the conflicts has been resolved, nor there are signs that they will be shortly: they all remain “frozen” *sine die*,

[2] Nicaragua, Venezuela and few insular micro-States of the Pacific Ocean.

in a condition that has been defined "*no peace no war*" [4], along *de facto* militarised borders, which represent almost insuperable barriers for the mobility of people, goods, ideas.

Results and discussion

Territorial fragmentation and regional (dis)integration

External players, such as the EU or academic bodies, often regard the SC as an integrated region, with institutions and representations organized accordingly. But this regional approach, as previously stated, does not reflect the situation on the field, which is characterized by a high level of territorial fragmentation instead. The most evident manifestation of this is the hostility between Armenia and Azerbaijan due to the NK, and the continued lack of diplomatic relationships between the two countries represents the foremost obstacle to integration. Georgia's failure in keeping the two separatist regions represents a further level of fragmentation. Finally, the embargo - and the resulting closing of the borders - which Turkey and Azerbaijan imposed on Armenia (again as a consequence of the conflict for the NK) excludes the latter from any perspective of integration in the infrastructural projects mentioned before.

One of the reasons of such reduced or lacking cooperation are the political, ideological and strategic differences that exist among the regional actors: Armenia, Azerbaijan and Georgia took separate roads, as a result of different political orientations **[2].** Georgia is manifestly oriented towards the West, as shown by its participation to some NATO missions, and it is the only country in the region to have signed an Association Agreement with the EU, including the "Deep and Comprehensive Free Trade Area" [10]. Armenia is deeply linked to Russia by political-diplomatic, military[3]and economic relations, being a member, the only one in the region, of the Economic Eurasian Union (EEU), of which Russia is clearly the "*senior partner*". Azerbaijan, instead, with its oil revenues can afford the luxury of "juggling" between opposite views and even of seeking an individual role on a regional level.

Border (re)organization

During the Cold War, the borders dividing the Soviet Union from Turkey and Iran, although difficult to cross, were stable and well defined. Since 1991 this is no longer true: the fall of the Soviet Union, the birth of three new independent States in the SC and the reorganisation of borders that followed put an end to a long period of relative regional stability and low intensity of international relations.

From the point of view of external borders, Georgia and Armenia replaced USSR in its border with Turkey (not considering an 18 km section that marks the border between Turkey and the Azerbaijani exclave of Naxçivan), Armenia and Azerbaijan in that with Iran.

Open State borders

There are open and functioning borders between sovereign States, characterized by a degree of openness that is commensurate with the post-soviet standards, that is, those of a geopolitical space that does not shine for its free circulation of people and goods, but nonetheless fall within the canons of "normality". Borders belonging to this category are those between Georgia and Azerbaijan, Georgia and Armenia, Georgia and Turkey, Azerbaijan and Russia, Azerbaijan and Iran, Armenia and Iran. An interesting case, and one relatively close to western standards, is that of the Sarpi point on the Turkey-Georgia border on the Black Sea, characterized both by an intense crossborder trade exchange and a high circulation of people, in both directions: Georgian workers that cross the border every day and Turkish tourists, to which are added Russian tourists headed to Turkey (Fig. 3).

Closed State borders

This is mostly the case of the borders that Armenia shares with Turkey and Azerbaijan, which were closed after the embargo imposed on Armenia as a reprisal for the support given to the NK "compatriots" (Fig. 4). This situation, as already stated, represents a major impairment for Armenia, which is excluded from the current infrastructural projects for the transportation of goods and hydrocarbons. Moreover, it constitutes the main obstacle to a real perspective of regional integration. Strictly speaking, the Russia-

[3] Armenia joins the "Collective Security Treaty Organization" (CSTO).

Georgia border falls into this category as well, but it is actually more correct to include it in the next one, given its less-than-full closure.

Fig. 3 Georgia-Turkey border (Sarpi, Georgia)
[Source*:* L. Zarrilli]

Fig. 4 Armenia-Turkey border (Margara, Armenia)
[Source: L. Zarrilli]

"Partially open" State borders

Despite the prolonged hostility between the two Countries, exacerbated by the events of August, 2008, in March of 2010 the Kazbegi (Georgia) - Verkhny Lars (North Ossetia) checkpoint along the Caucasus range (Dariali Gorge) was reopened (Fig. 5). This decision was due to economic, more than political, reasons: the total closure of the Russia-Georgia border, following the 2008 conflict, had seriously penalised the transit on the North-South route, with major inconvenience not only for Armenia but also for the exchange between Russia and Iran. Even from the Georgian point of view the opening of the checkpoint represented an opportunity: besides the income deriving from trade, it opened the possibility to benefit from a tourist flow heading for Georgian or Turkish tourist areas. Considering this, the Georgian government, surprisingly enough given the mood of its relationship with Moscow, introduced a *no visa regime* for Russian citizens.

Fig. 5 Russia-Georgia checkpoint (Kazbegi - Verkhniy Lars)
[Source: L. Zarrilli]

Administrative borders turned into "iron curtains"

The former administrative borders of Abkhazia/South Ossetia and NK towards, respectively, Georgia and Azerbaijan, are today small "iron curtains" that separate the breakaway regions from the parent States (Fig. 6). Juridically, they are "cease-fire" lines, heavily militarized and constantly guarded. In fact, they are considered by separatists as fully-fledged State borders, very difficult to trespass but not necessarily static:the "cease-fire" line between Georgia and South Ossetia has been several times moved forwards by separatists, who in this way have incorporated more strips of Georgian territory[4].

[4] "The Russian Army, stationed within the territory of separatist South Ossetia, is used to take over significant areas of the Georgian territory, as a result of a ʽwild demarcation'. In the recent period, more attempts of shifting the demarcation line were made, through labelling the areas close to the Tsitelubani village (Gori area) with the "border signs". Due to this operation, a small portion of the strategic Baku-Supsa pipeline which transfers the crude oil between the Caspian Sea and the Black Sea (between Asia and Europe) has been located within the territory of Ossetia."(www.defence24.com/georgia-russian-army-shifted-the-border-taking-over-a-fragment-of-the-strategic-pipeline").

Fig. 6 Georgia, barricade along the "cease-fire" line with South Ossetia
[Source*:* L. Zarrilli]

State borders turned into "gateways"

Conversely, the segments of the Russia-Georgia and Armenia-Azerbaijan State borders that are under the control of separatists do not exist as such. One of the authors of this paper have had several times the opportunity to cross the "border" between Armenia and the Azerbaijani territories under the control of the NK separatists: at the checkpoint no particular formality is required for the citizens of the Republic of Armenia, while "tourists" simply have to bring a paid entry visa, easily purchased. The crossing of the checkpoints of Russia, on one hand, and Abkhazia and South Ossetia, on the other, is probably not as simple[5], but certainly possible. Essentially, instead of State borders, that would likely be closed because of the bad relationship among the States involved, we find what we might define as more or less comfortable "gateways" to and from Russia or, in the case of NK, to and from Armenia.

Conclusions

In the absence of significant turns, the regional scenario seems condemned to a constant condition of instability and lacking integration, which contributes to strengthen the "barrier effect" already inherent in the border trim, as shown in the paragraph above. Thus it seems that the SC is in a sort of vicious circle: the political fragmentation prevents regional integration; the lack of regional integration consolidates the political fragmentation. In fact, the few forms of integration that exist today always exclude at least one of the three Countries, which ends up accentuating diversities and fueling the aforementioned vicious circle.

It would not be excessive to assert that a "multi-layered" condition of conflict is in place in the region, in which each layer ends up reinforcing the unrest of the others: among sovereign States (Armenia vs Azerbaijan; Armenia vs Turkey; Georgia vs Russia); among sovereign States and breakaway regions (Georgia vs Abkhazia; Georgia vs South Ossetia; Azerbaijan vs NK); among regional organisations (EU vs

[5] The authors didn't have the possibility to verify personally, but this is what can be seen from various on-line reports.

EEU; NATO vs CSTO); between political leanings (Western-oriented, i.e. Euro-Atlantic vs Russianoriented, i.e. 'Russian World').

The benefits of a regional integration are obvious and the conditions for a change of route, although difficult, might be created if there was the political will to do so **[11]**, but the forces that work against that, both internally and externally (nationalisms, authoritarianism, ancestral hostilities, Russian interferences), are still very powerful, nor the international scenario seems today oriented towards a spirit of collaboration and openness.

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RISK FACTORS FOR THE FORMATION OF AN AGRICULTURAL ENTERPRISE STRATEGY IN THE DIGITAL ECONOMY

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Abstract

Developing a digital strategy can be seen as a means of reducing uncertainty in the future activities of an agricultural enterprise. In this paper, the theoretical basis for the formation of the strategy of an agricultural enterprise in the context of the introduction of digital technologies is formulated.

Methods for identifying risk factors in the strategic management of an agricultural enterprise are proposed. In this study, the strategy of the organization will be understood as a set of mutually agreed strategic decisions aimed at realizing its mission, achieving balanced development, preserving the integrity and maintaining stable successful activity. An agricultural enterprise strategy can be developed and implemented on the basis of multilateral platforms or within the framework of socio-economic ecosystems.

Modern digital technologies allow effective functional and managerial interactions of commercial enterprises, government agencies and non-profit organizations.

These interactions are aimed at solving such strategic tasks of an agricultural enterprise as reducing transaction costs and reducing time spent on finding information about suppliers and buyers, as well as studying markets.

Key words: agricultural enterprise, strategy, digital technologies, risk factors, multilateral platform

Introduction

Digital technologies are changing the interactions between economic actors. The opposite is also true: economic agents influence the direction of technological development and invest only in those technologies that bring additional benefits. Modern technologies are developing rapidly and also they quickly become obsolete. Many enterprises of the agricultural sector are difficult to adapt to this.

Developing a digital strategy can be seen as a means of reducing uncertainty in the future activities of an agricultural enterprise. In the process of identifying risk factors in the formation of an enterprise strategy, opportunities are identified for interfering with an enterprise's activity or making erroneous strategic decisions that can lead to losses.

The condition for the effective functioning of the enterprise is to determine the purpose of its activities. Experience shows that to ensure the effectiveness of management, the formulation of the global goal of an enterprise's activity is insufficient. Usually the decomposition of the enterprise goal is carried out by the elements of the organizational structure, giving each organizational unit its sub-goal. The achievement of each sub-goal, according to the management of the enterprise, should contribute to the achievement of the overall goal of economic activity.

Information on possible negative events is objectively necessary for the management and employees of the enterprise to implement the chosen strategy. When using the life cycle model [1], the main set of threats and weaknesses for an agricultural enterprise is revealed. This set depends on the stage of the life cycle, and these details are important to consider when forming a digital strategy. Hierarchical decomposition of an enterprise's strategic goals can help coordinate and align these goals during the creation and development of strategic decisions.

Agricultural enterprises in both developed and developing countries have special characteristics that lead to high transaction costs. These characteristics of rural areas include relatively low population density, a significant geographical distribution of consumers and producers, and relatively weak infrastructure [14]. Thus, transaction costs, when consumers and producers interact in rural areas, differ from the costs of enterprises in urban areas. The level of transaction costs in rural areas depends not only on these characteristics, but also on the formal and informal institutional environment, including the existence of trust and social relations [18].

Within the framework of this study, the strategy of an agricultural enterprise in a digital economy will be understood as a set of strategic decisions aimed at implementing its purpose, achieving balanced development, maintaining integrity and maintaining sustainable success.

In the framework of this study, the strategy of an agricultural enterprise in a digital economy includes a set of strategic decisions aimed at realizing its mission, achieving balanced development, preserving the integrity and maintaining sustainable success.

Materials and methods

To identify risk factors for the formation of an agricultural enterprise strategy, it is proposed to describe existing strategies. For example, rural non-profit organizations implement various integration strategies, such as maintaining common infrastructure, providing social services [15], managing the use of common community resources [12], or, in the case of some agricultural cooperatives, the organization of sales of products and supplies, and the provision of technological services [13].

Trends in society emerging in the development of digital technologies are being identified. The influence of individual factors on the development of enterprises in the digital environment is analyzed. The strategy of the agricultural enterprise is formed on the basis of this analysis.

The process of forming an agricultural enterprise strategy and identifying risk factors is considered within the framework of a socio-economic ecosystem that is related to the external environment of the enterprise or the interaction of a set of enterprises using a common key technology [7].

With the development of the information and communication environment, an enterprise can carry out its activities simultaneously in the digital and economic spaces that are currently intertwined. The invention of the block-chain technology, the creation of cryptocurrency [10], the development of many complex financial transactions in the virtual space show that there have been technologies for extracting, converting, transferring and storing financial resources or "value". This is a fundamentally new type of financial technology. These technologies implement distribution and exchange processes in the socio-economic space. When switching to new technologies, the cost of transactions may drop significantly. Financial resources and services may become more accessible for a larger number of economic agents, including agricultural enterprises.

Early research [3] showed the interest of economic agents from the agricultural sector in online interactions with other economic agents, but digital technologies were not sufficiently developed. Recently, more than a thousand new technology companies in the agricultural sector have emerged, specialized online communities are being formed [6], which use a dynamic process of collaboration and introduce innovations in interconnected series.

The accumulation of data during practical activities and their structuring into knowledge bases allow specialists to set and solve problems in the subject area. For example, information about crops, fertilizer use, crop rotation, rainfall, and dozens of other indicators using special software allows such large companies as Bayer, Syngenta, or BASF [11] to analyze the collected data in order to predict the most profitable from the point of view of future yields a combination of seeds, fertilizers and pesticides.

Multilateral platforms for joint ventures are a relatively new phenomenon in the socio-economic sphere. Completely new ways of serving existing needs are created with the introduction of new technologies. Existing production chains are disrupted, and non-linear forms of information and communication interaction with implicit spatial and temporal boundaries are emerging [19]. For example, if competitors gain access to global multilateral platforms for research, development, marketing, sales and distribution, they can quickly crowd out traditional suppliers, improving quality, speed or cost of delivery. The main trends in society that are emerging as a result of the development of digital technologies and may affect the implementation of the strategy of an agricultural enterprise can be represented graphically (Figure 1).

Modern digital technologies allow effective functional and managerial interactions of commercial enterprises, government agencies and non-profit organizations. A unified system of standards and protocols for the exchange of data between economic agents is a prerequisite for such integration strategic decisions as the coordination of the production of products and services of different enterprises.

The strategy of a modern agricultural enterprise is formed in close relationship with its socio-economic ecosystem [2]. The enterprise ecosystem is a localized complex of economic agents, technological and business processes, innovative projects and infrastructure systems. The ecosystem operates in the external environment for a long time due to the sustainable reproduction of resources [9]. The enterprise's ecosystem consists of four mutually complementary and jointly functioning subsystems and includes: an object subsystem, an environmental subsystem, a project subsystem, and a process subsystem (Fig.2).

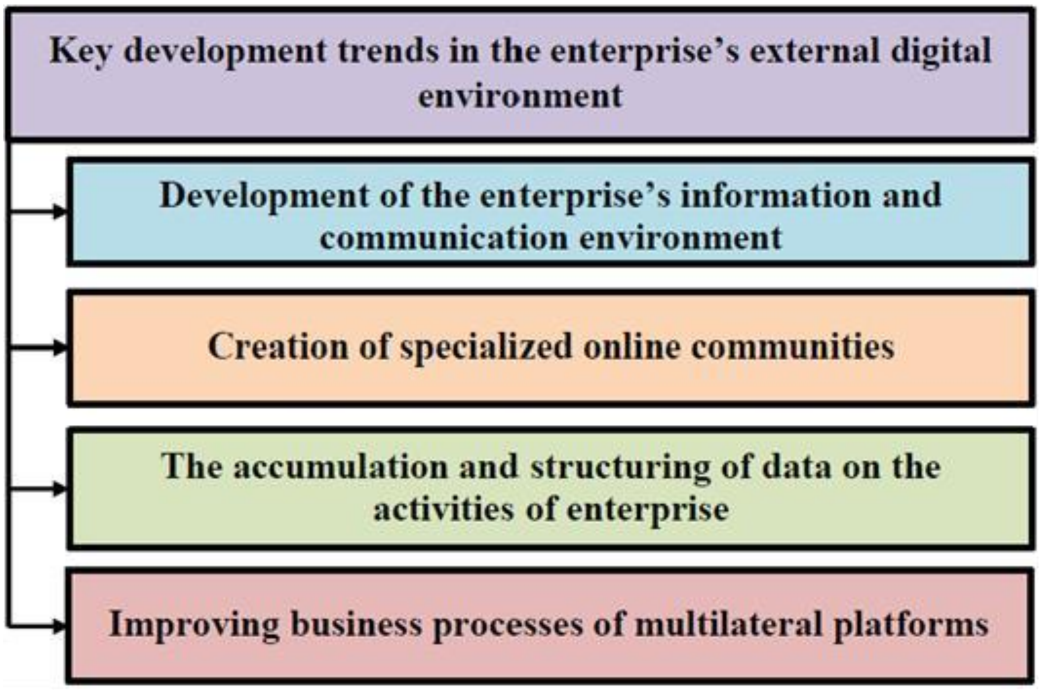

Fig.1. Key trends in the development of digital technology

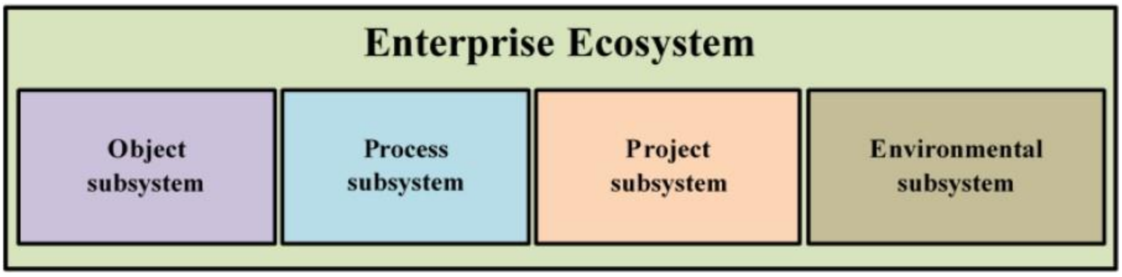

Fig.2. Structure of the enterprise ecosystem

Object subsystem includes the assets of the company, both tangible and intangible. The restrictions of this subsystem in the space will be understood in two ways: as real limitations of tangible assets in physical space, and as limited in virtual space for intangible assets. Process subsystem for the enterprise can comprise internal and external technology or business processes. Project subsystem is a set of implemented various projects in the enterprise. Environmental subsystem can be considered as socio-economic and cultural conditions and traditions in which the company operates, and the staff and units interact.

The model for representing the enterprise ecosystem as a set of subsystems: object, process, project and environmental, provides a simple two-level hierarchical decomposition in which the enterprise ecosystem is at the top level and four subsystems at the bottom level (Fig. 2). Structuring the economic space of the enterprise allows to identify subsets of economic risk factors grouped by the relevant subsystems.

Results and discussions

The introduction of new tools of digital technologies can be provided in the development of the strategy not only as a factor in the external development of the agricultural enterprise, but also for the automation of internal processes, for example, for the preparation of management decisions.

At the same time, when formulating an enterprise strategy, it is necessary to identify risk factors. The strategic planning horizon covers long periods of enterprise activity, and the benefits of new technologies and the period of their possible use are not fully understood. Therefore, one of the risk factors may be the risk of an unforeseen reduction in the lifetime of certain digital technologies.

The awareness of employees about the objectives of the enterprise may not be sufficient for the effective organization of activities. In this case, there may be a risk factor of opportunistic behavior of members of the workforce in the implementation of the strategy of the enterprise.

The plan for the implementation of the strategy should define the set of "mile stones" in which in which intermediate results should be achieved. The absence of such a plan can lead to the emergence of a risk factor for the failure to achieve the strategic goals of the enterprise, both intermediate and final.

New digital technologies that have appeared on the market may seem “too” revolutionary. The enterprise will spend considerable time on the introduction of new technology. For this reason, there may be a risk of lag in the introduction of digital technologies and the loss of competitive advantages of an enterprise in the market.

Issues related to the specifics of the strategic development of agricultural enterprises in the digital economy are causing discussion:

- rise of large-scale farming (agroholdings) [5];
- greater public demands for CSR activities, especially of large farms [8];
- disappearance of some of the traditional types of cooperatives and nonprofits (that directly addressed transaction cost problems and other market failures); this could be explained based on [4,16];
- emergence of new types of nonprofits (advocacy NGOs, professional associations, bargaining associations); this could be explained based on Kenneth Boulding’s theory of Organizational revolution, summarized by [17];
- It is possible that in the future agricultural enterprises will be natural elements of ecosystems, including multilateral technological platforms.

Conclusions

Identification of many risk factors is the most important stage in the formation of the strategy of the agricultural enterprise in the digital economy. Creating a database of statistics that captures possible decision-making options and risk factors can help in the future not to miss significant risk factors. The main task in the face of uncertainty is the timely detection of risk factors and then the minimization of possible negative consequences.In this paper, an attempt was made to structure the various fields of activity of an agricultural enterprise within its ecosystem. Risk factors can amplify or weaken simultaneous negative action at interaction of subsystems of the enterprise.

On the one hand, the development of a strategy may provide for the coordination of interactions between enterprises, authorities and non-profit organizations, which allows to reduce the cost of selecting contractors, marketing research. On the other hand, a strategy based on the technology of analysis of “Big data” within the enterprise will allow to apply more effective management decisions.

The analysis of the strategic process indicates that at the stage of strategy formation it is necessary to monitor risk factors that may become an obstacle to the successful implementation of the enterprise strategy.

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THE ASSESSMENT OF DEGRADATION AND ANALYSIS OF PEDOLOGICAL VARIABILITY IN ARAGATS MASSIF

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Abstract

The main purpose of the study is to explore and evaluate the pedological variability in Aragats massif at altitude. As a result of processing the laboratory samples, which were 49 from 10 soil profiles, a number of soil property changes have been characterized by depth. One of the major problems was to find out the degree of soil degradation on the southern slopes of the Aragats massif.

By 2002, 81,9 % of the soils of the Republic of Armenia (RA) were influenced by various forms of degradation. The studies have shown that the main reason of the soil degradation on the southern slope of Aragats is overgrazing. It is more obvious that a few centimeters of the upper layer of the soil are compressed. On the slopes of Aragats overgrazing was and still is the main reason for erosion and soil degradation as the semi-nomadic lifestyle is still active. As a result, most of the atmospheric precipitation becomes a surface flow, because of the high compression of upper horizons, the volume of absorbing water decreases, which, in its turn, increases the intensity of erosion processes.

Key words: Massif Aragats, pedological variability, soil profiles, soil degradation

Introduction

Nowadays, soil degradation on pastures due to overgrazing and agricultural land use is one of the major threats to the environment in Armenia. Especially in mountainous regions consequences of grazing and mismanagement can have a huge influence on erosion processes causing degradation through landslides, mud flows or wind erosion and those changes have caused mountainous landscape degradation. In semi-arid regions such as the central Armenian highland, degradation of soils can occur in various forms. On the one hand there is soil compaction due to cattle grazing and / or inappropriate land use management, but the use of heavy machines on agricultural land leads to negative effects on soil, too.

The unprecedented development of humanity and economy has resulted in changes of different spheres and their researches are becoming more and more relevant every day. One of these problems is the pedological changes and their degradation. The problem is even more complicated when the studied area is a mountainous region and we have to take into consideration a number of factors affecting those changes.

Materials and methods

The study area, Mount Aragats, is situated in the center of Armenia, north-west from Yerevan, in Aragatsotn region. We studied mainly the southeastern slopes of Aragats. 10 soil profiles have been studied at altitudes from 2115 to 3149 m (Fig. 1), taken 49 samples of which were identified as burning losses, mechanical composition of soil, acidity, electro conductivity, cation exchange capacity (CEC) and soil base saturation. Soil profiles are described using German Soil Systematics KA5 [1].

Results and discussions

There are different factors such as location, slopes and their position, climatic conditions effect on the soil development processes and future pedological changes at altitude (Fig. 2). Since all the investigated profiles are located on the southern slope of Aragats and covered mainly with step landscape, the soil is rapidly dried up by the effect of sunlight, and, therefore, the soil formation processes are slower compared to the northern slopes. The landscape and human activity have a significant impact on the soil development which is very clear visible comparing Ar1 and Ar2 profiles. Moreover, grazing has a major impact on soil formation in Aragats massif.

Ar2 profile is located in a forestry area where there is no grazing, so a large amount of organic matter is accumulated there. Compared with the other profiles, the soil remains moisture under the trees, thus, more favorable conditions for soil formation processes. However, the slope angle is quite big which causes active erosion and deep development of the soil is impossible in these cases.

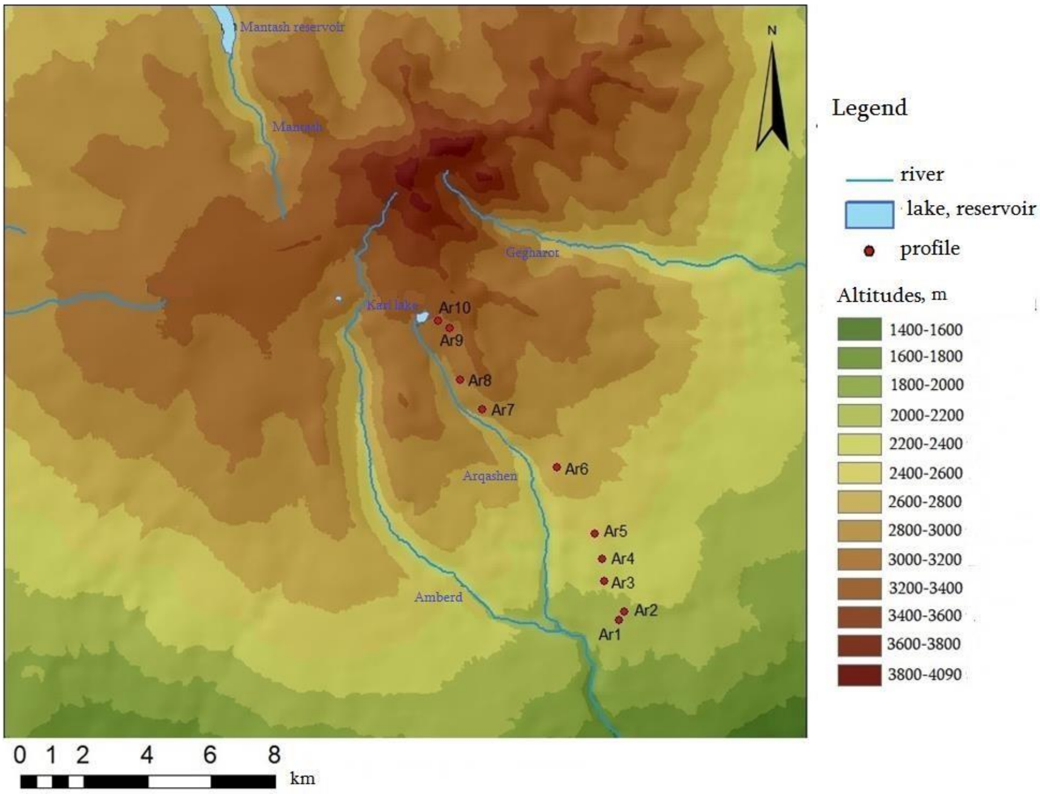

Fig. 1. A schematic map of soil profiles on Aragats massif

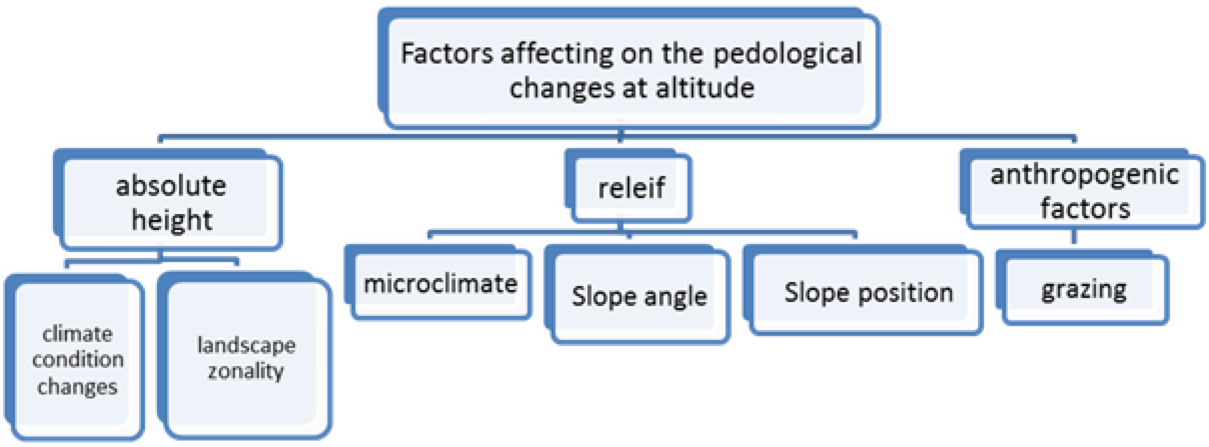

Fig. 2. The main factors influencing on the pedological changes in Aragats

According to the laboratory results of the samples, several factors in Ar1 profile cause poor soil development. The surface is grassy, which means that the sun's rays immediately fall on the ground and it quickly dries out. There is also a negative impact by grazing as a result of which a great loss of humus occurs, as well as the upper layer of the soil is condensed. The latter, in its turn, reduces the penetration of water into deeper horizons, resulting in dry land, with no clear genetic horizons. It can be said that Ar2 profile has a lower acidity value than Ar1 profile, which is mainly explained by the difference in humus content [2].

Large differences have also been observed between Ar9 and Ar10 profiles, which are at almost the same height. The main cause of these differences is a different microrelief.

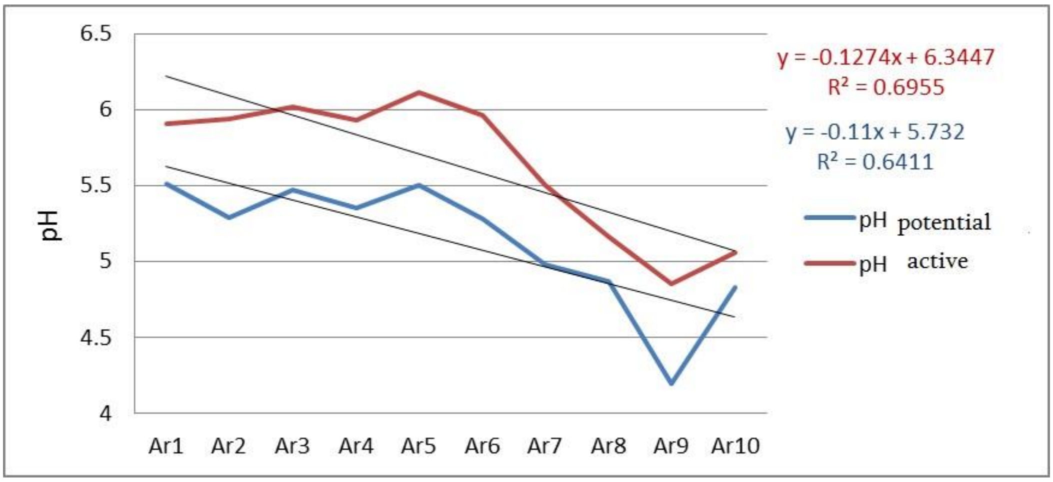

Fig. 3. The upper A horizon acidity changes at altitude

It is visible form Fig. 3 that the potential and active acidity values of the upper A horizons of the soil are decreasing from low altitudes to high. This is due to the increase in the amount of atmospheric precipitation. Moreover, the correlation link between height and acidity is quite reliable (r = 0.8), which speaks clearly about the fact that in Aragats the values of the acidity decreases in A horizons at altitude (Fig.3).

The value of active acidity, except for Ar6 profile, always grows from surface to depth, which can be explained by the weakening of biological activity [2].

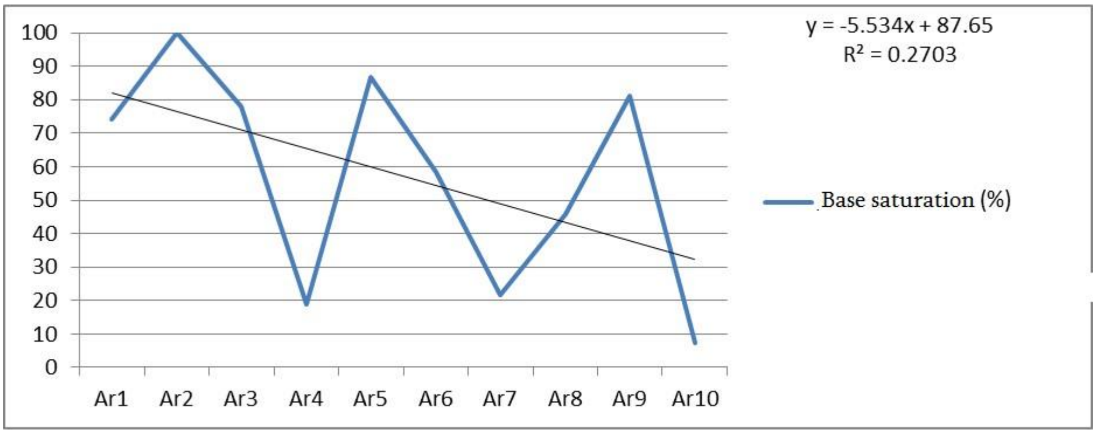

Fig. 4. Base saturation changes of A horizons at altitude

The altitude difference between Ar3 and Ar4 profiles are about 100 meters and both have low clay content. These soils are essentially different from each other, which can be related to microrelief and slope position differences. Ar4 profile has a high level of base saturation and the largest content of calcium compared to all profiles. Conversely, Ar4 profile has a much lower base saturation compared to Ar3 and Ar5 profiles, with almost equal acidity conditions. Since Ar4 profile has a relatively big slope angle, it has had a great impact on it, causing erosion, which explains the smallest capacity of humus in the A horizon.

The laboratory results have shown that base saturation is lower than the average for the higher profiles (Fig. 4). At the same time, potential acidity increases by height. This can be explained to some extent by the differences between the parent rocks, which is clear for Ar7 profile. In higher profiles, soil moisture increases due to increased precipitation, which, in turn, affects many properties of soil, including acidity. The major cations that are dominant in saturation are calcium and magnesium. Ar7 profile has a high-calcium saturation value compared to other profiles.

Soil absorption is the ability to absorb and dissolve in water, as well as to absorb and store water vapors. This is one of the important properties of the soil; its role is great in the processes of soil fertility. In the case of high absorption, easily digestible nutrients are stored in the soil and are not washed or taken by water. The absorption capacity is connected with the value of cations: the higher the cation value, the greater its absorption energy or exchange capacity [3].

In Aragats, as the relief is very variable, the cation exchange capacity (CEC) is also very various from one profile to another: for instance, it varies from 9,11mmol /kg (in Ar3/6 sample) to 42,46mmol/kg (in Ar9 / 2 sample). The high values are explained by the high content of humus (Fig. 5).

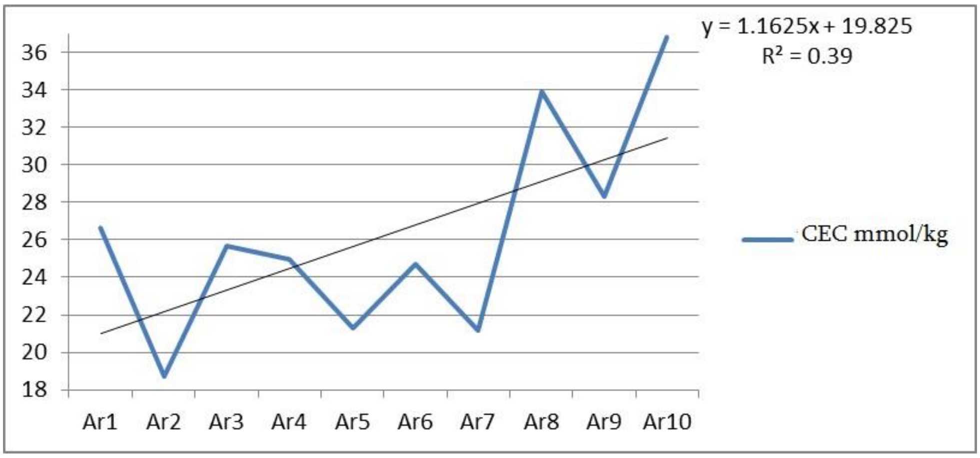

Fig. 5. Cation exchange capacity changes of A horizons at altitude

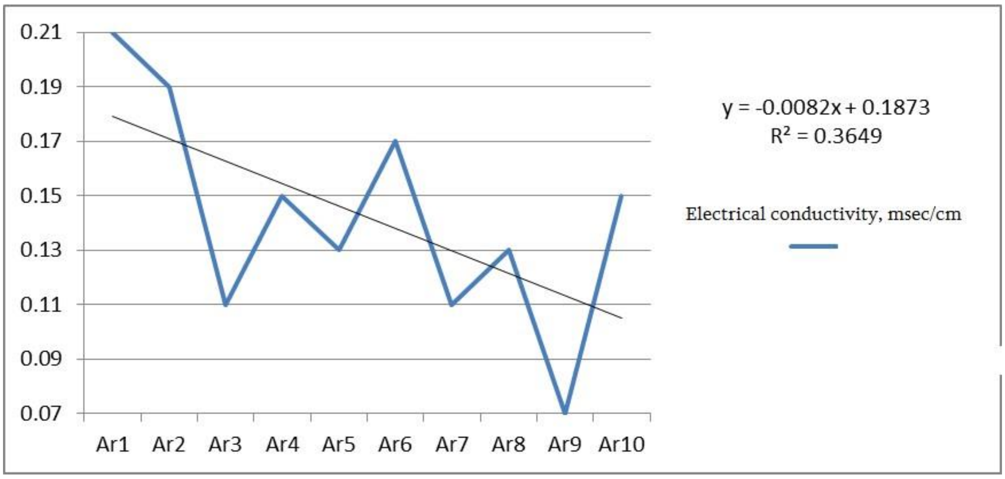

Fig. 6. The electrical conductivity changes of A horizons at altitude

The electrical conductivity values are generally higher in the upper A horizons of the soil. As it is seen from the graph of the trend line **(**Fig.6.), electrical conductivity decreases at altitude. The electrical conductivity of the profiles ranges from 0.03 to 0.28 msec/cm which, however, in both cases involves low saline content and does not adversely affect plant growth [4].

Humus content in the soil was quite complex, as the adjusted values of the burn losses were quite high. Additionally, the high values of burning losses are not always linked to high humus content, which affects the value of various clay particles and salts contained in the soil. Therefore, the values of burning losses were mainly used for comparison purposes. However, it is clear from the results that the humus content in the upper a horizons grows at altitude.

The most common soil type is regosol, which is common from 2450 to 3050 meters a.s.l. in Aragats. Regosol is a soil with low capacity of soil erosion, the main cause of which is low humidity and angles of slops. In the case of a larger amount of moisture penetration, the soil-warming process takes place intensely and a number of soil processes are activated, such as smaller particles (less than 0.002 mm) moving from the upper horizons to the deeper horizons. It refers to Ar2 and Ar9 profiles that are at different altitudes, but are characterized by similar processes. Ar4 and Ar3 profiles, which are about 2300 meters above sea level, are described as brown soils with high humus content. The color of this soil affects the strongly colored iron compounds in the soil.

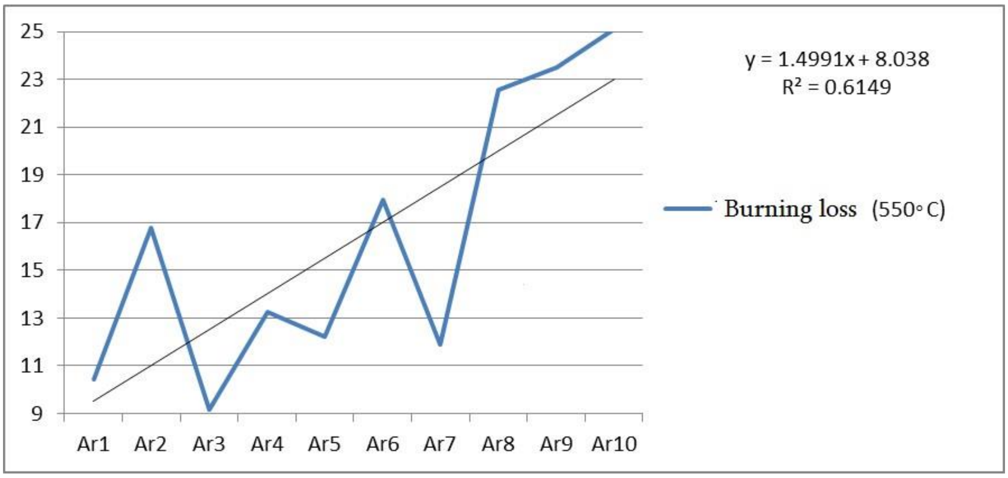

Fig. 7. Burning loss changes in the upper A horizons of soil profiles at altitude (%)

Conclusions

The main factors influencing on the pedological changes in Aragats massif are the altitude, relief differences, different climatic conditions, and, of course, grazing which substantially changes natural soil development process.

The studies have shown that the main reason for soil degradation on the southern slope of Aragats is the overgrazing. It is most apparent that a few centimeters of the upper layer of the soil are available in all 10 profiles. It is clearly seen in laboratory studies of soil density and strain. In Ar2 profile, which is probably the only one that has never been exposed to grazing (as it is in the forest area); soil compression is less than 4 cm above the depths of the deep horizons. And on Ar1 profile of the same height, where vegetation is grassy and subjected to grazing, the picture is exactly the opposite: the upper layer of the soil has an incomparably greater compression than the lower horizons.

Most of the atmospheric precipitation gets surface flow because of the high concentration of upper horizons, the number of absorbing water decreases. In addition to increasing the germination of the upper layer of the soil, animals also harm the vegetation, and in turn increases the intensity of erosion processes. Therefore, areas with high erosion risk due to relief position should be moderately used or even not used for grazing purposes, but should also be accompanied by other erosion measures, such as vegetation changes. Feeding also impedes the growth of any kind of tree vegetation in the area, which will protect the soil from erosion in natural conditions.

Due to grazing the number of organic materials have decreased in the soil which later would be stored and decay into humus. In other words, grazing also impedes the process of humus production in the soil.

Acknowledgements

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SESSION 3. ENVIRONMENT DEGRADATION AND POLLUTION

ON THE INFLUENCE OF LANDSCAPE ON THE CONTENT OF LIGHT AEROIONS IN DIFFERENT REGIONS OF GEORGIA

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Abstract

The importance of study of the light ions content in the atmosphere is well known. The content of light ions in the atmosphere plays important role in molding of the physiological state of population.

In this work some results of studies of the influence of landscape on the ionizing state of air environment in different regions of Georgia in recent years carried out. The data about the content of aeroions in Tbilisi and some locations of Western Georgia with different types of landscape (urban, forest, park, gorge, waterfalls, the coast of rivers, etc.) are represented. In particular, it is shown that even in the limits of the strongly contaminated city the landscape has vital importance for creating the medium ecologically favorable for human health (Tbilisi National Botanical Garden, territory of Tbilisi Sea, etc.). The results of work can find practical application for the development of health resort- tourist industry in Georgia.

Key words: light ions, landscape, bioclimate, ecology, health resorts and tourism

Introduction

The formation of ions mainly occurs as a result of the ionizing radiation (cosmic rays, gamma radiation of soil, radon and the short-lived products of its decay) [1]. Sometimes in the limited spaces there are other natural and anthropogenic sources of ionization (hydro-ionization, ionizations with the thunderstorms, etc.) [2, 3]. The disappearances of ions it occurs due to their recombination, attachment to the aerosol particles, and also adhesion to different surfaces [1,4,5]. Accordingly, the content of aeroions, besides natural ionization, is determined by weather conditions, ecological state of the surface atmosphere, by nature of landscape [1, 4-7].

The content of light ions in the atmosphere plays the significant role in molding of the physiological state of people and, simultaneously, it is the indicator of the air purity [1]. Under the "good weather" condition, the minimally necessary level of the sum light ions content for the favorable influence on the health of people is ≈1000 cm^{-3} and more. If the sum light ions concentration is ≈600 cm^{-3} and less, the following negative physiological action on the human organism are observed: fatigue, weakening attention, retarding of reactions, worsening in the memory, headache, the disturbance of the regime of blood pressure, etc. Air, saturated by the high content of ions (4500 cm^{-3} and more), possesses therapeutic properties - optimization of blood pressure, positive influence on the course of the diseases of respiratory organs, bronchial asthma, antiseptic action, etc. The very high concentrations of light ions (100000 cm^{-3} and more) negative affect the health of people [1, 2, 8, 9]. Therefore, during the determination of ecologically unfavorable and favorable environments for the health of people special attention is paid to the analyses of the content of light ions in air. In particular, special attention is paid to the places with the waterfalls, fountains, national parks, preserves, forests, alpine regions, mountain gorges, the coast of rivers and sea, the tectonic breakings (increased concentration of radon), karstic caves, etc., where the ionization level of air can be suitable for the sessions of ionotherapy [10-12]. Some results of the analysis of distribution of light aeroions content on the territory of western Georgia, and also generalization of early studies [1-6, 10, 11], are represented below. The role of landscape in shaping of the ecological conditions of locality is shown.

Materials and methods

Light ions concentration (cm^{-3}) measurements in Tbilisi were conducted 4 times a day at height 3 floor of the building of the cloud chamber of the Institute of Geophysics (stationary point of measurement, 8 meters above the level of soil, 41.72º N, 44.79º E, the height - 450 m above sea level), into 9, 12, 15 and 18 hour (in the winter season - 17 hours), and in 20 points in different city locations. Stationary monitoring by Gerdien's type instruments was conducted [1].

Mobile studies with the aid of the portable ions counter of the production of firm "AlphaLab, Inc." are conducted (20 populated points of Tbilisi, 462 measurements; some health resort – tourism locations of Tbilisi, 270 locations of Western Georgia, etc., single measurements).

The following designations will be used below: n (+) - concentration of positive light ions, n (-) - concentration of negative light ions, n = n (+) + n (-) – sum light ions concentration. For purposes of the savings of place the dimensionality of the light ions concentration (cm-3) in the figures is omitted. In the work the data of measurements 2007-2015 are used.

For the data analysis standard statistical methods are used. Designations - conventional. The maps of the distribution of the aeroions content with the aid of the "Google Earth" program are built.

Results and discussions

Results of investigations on the Fig. 1-4 and in Tab. clearly are presented.

Fig. 1-3 depicts maps of the distribution of values of n on the territories of Western Georgia, populated parts of Tbilisi city and Tbilisi Botanical Garden. In the Tab. the statistical characteristics of sum light ion concentration in air in Western Georgia and Tbilisi are presented. Fig. 4 the renovated block diagram of the content of light aeroions in different health resort- tourist regions of Georgia is presents, given earlier in the work [2].

Fig.1. Content of sum light aeroions in 270 locations of Western Georgia.
At the top of the picture is a scale from 400 to 3200 cm^{-3}.

Western Georgia (Fig. 1, Tab.1). Low concentrations of aeroions (n≈600 cm-3 and less) only in certain parts of cities Sachkhere, Tskaltubo, Zestafoni and Vani were observed (1.5 % of cases). The sum light ions content for the favorable influence on the health of people (n ≈1000 cm-3 and more) in 93.7 % of cases were observed. Populated part of Tbilisi (Fig.2., Tab.1). On average, unfavorable for human health concentrations of light aeroions in five points of Tbilisi were observed (Pekini str.; Varketili, near the metro station; Vake, G.Svanidze str.; near the metro station "Avlabari"; Heroes Square) - 23.8 % of cases. The values of n for the favorable influence on the health of people in six points of Tbilisi were observed (Lilo; stationary point of measurement; Vazisubani; Chichinadze str.; Moscow av; Zemo Ponichala) -28.6 % of cases. Tbilisi Botanical Garden (Fig.3, Tab.1.). On the territory of the Tbilisi Botanical Garden of low values of n (≈600 cm-3 and less) was not observed.

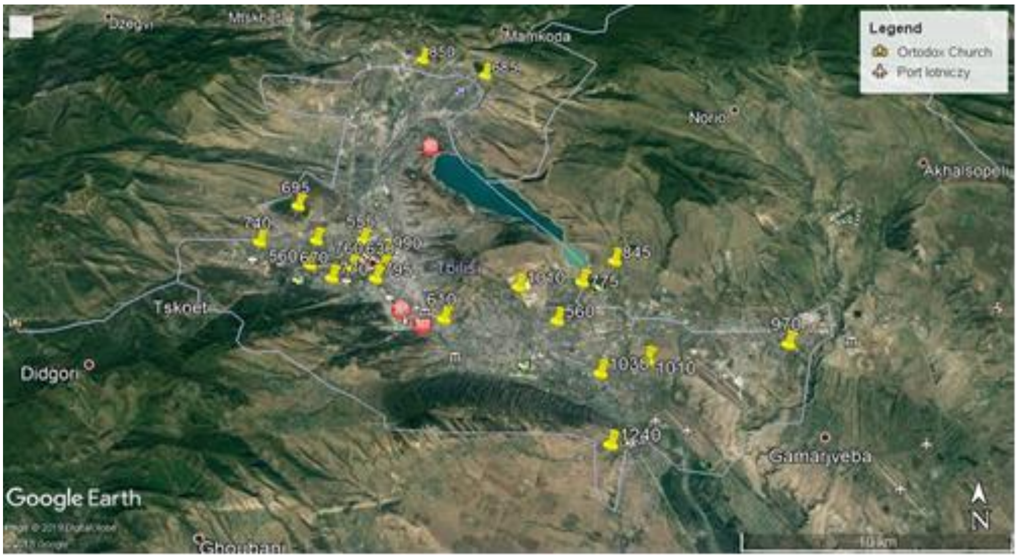

Fig.2. Average content of sum light aeroions in 21 locations of populated part of Tbilisi.

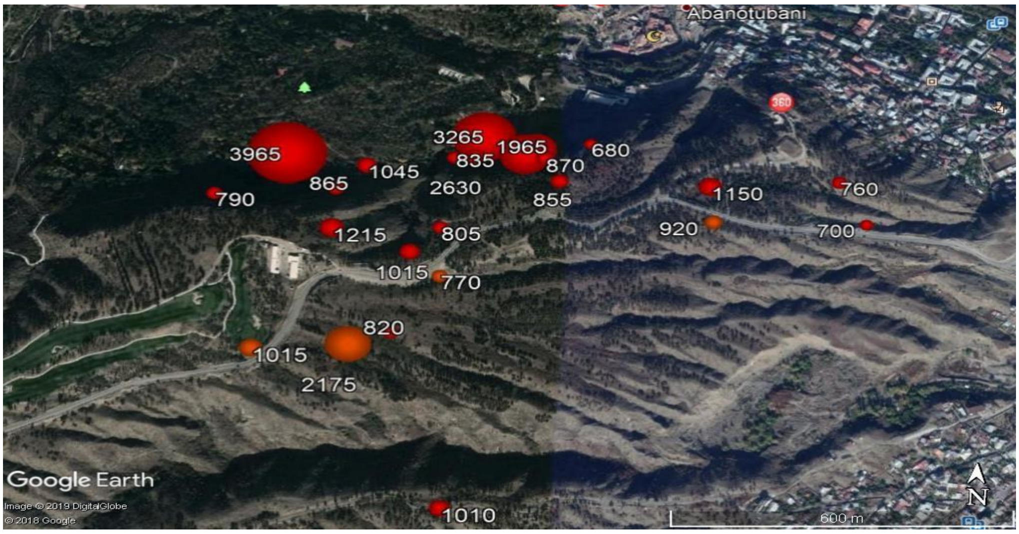

Fig.3 Sum light aeroions concentration in 25 locations of Tbilisi Botanical Garden.

Table 1

The statistical characteristics of sum light ion concentration in air in western Georgia and Tbilisi

Location/ Parameter	Western Georgia (Fig.1)	Tbilisi (Fig. 2)	Tbilisi Botanical Garden (Fig. 3)
Min	450	556	680
Max	3250	1237	3965
Average	1878	797	1277
Range (Max-Min)	2800	680	3285
St Dev	541	186	856
C_v=100·St Dev/Average,	28.8	23.3	67.1
n≈600 cm^{-3} and less, %	1.5	23.8	0
n≈1000 cm^{-3} and more, %	93.7	28.6	48.0

The values of n ≈1000 cm-3 and more in 12 points were observed – 48 % of cases. The high concentrations of sum aeroions near the main waterfall with the height of 24 m (2630 cm-3), the small waterfall (3965 cm-3) and also under the Tamara bridge near the river Tsavkisi (3265 cm-3) are observed.

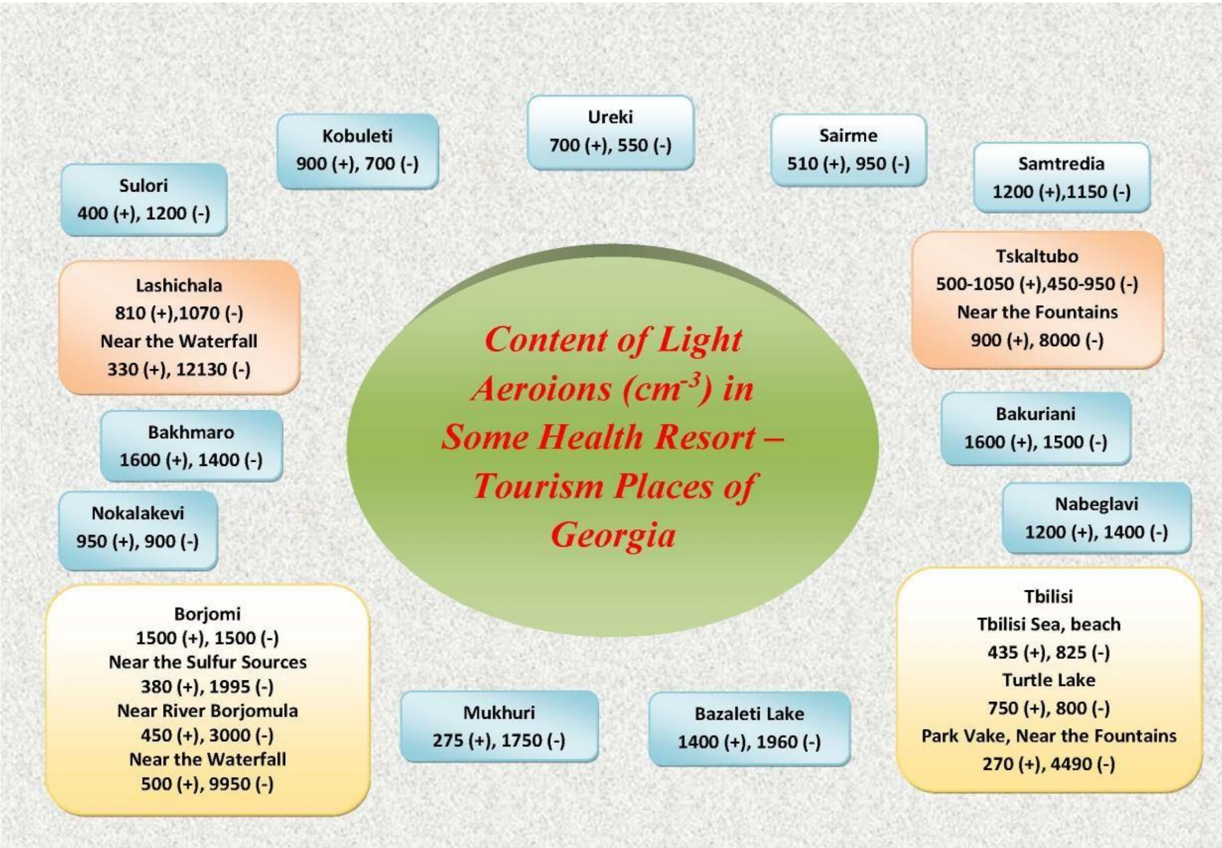

Fig. 4. Positive and negative light aeroions concentration in some health resort – tourism places of Georgia.

As it follows from Fig. 1-3 and Tab., ecological conditions in Western Georgia are much better than in the populated part of Tbilisi city (the average content of the values of n respectively are 1878 cm^{-3} and 797 cm^{-3}, the repetition of the values of n≈600 cm^{-3} and less corresponding are 1.5% and 23.8%). At the same time, in the separate districts of Tbilisi city the favorable for the health of people ecological conditions are observed, similar to the conditions in different health resort- tourist regions of Georgia (Fig. 4).

Thus, even in the conditions of urban landscape it is possible to find places with the acceptable ecological conditions for leisure, rehabilitations and treatment of people (forest and park zones, near the rivers, waterfalls, fountains, etc.).

Conclusions

The landscape of locality, together with other factors, plays important role in shaping of the ecological state of medium in the aspect of the ionization of air. The analysis of obtained data testifies not only about the need of retaining of natural landscapes (waterfalls, national parks, preserves, forests, alpine regions, mountain gorges, the coast of rivers and sea, the tectonic breakings, karst caves, etc.), but also adoption of measures for an artificial improvement in the ecological state of medium (increase in the areas of forests, the building of fountains, the creation of parks, the rehabilitation of those existing and the search for new recreational zones, etc.).

In the future we provided the continuation of studies in this direction.

Acknowledgements

Major portion of the works is executed within the framework of projects “Assessment of radon-hazard potential, residential exposure, lung cancer and COPD in West Georgia”, (Project STCU-3992, 2007-2009, 36 Month) and "Mitigation of negative action of photochemical smog on the living environment – important factor of the sanitation of ecological state of Tbilisi city", (Georgian National Science Foundation Grant NGNSF/ST08/5-437, 2009-2012, 36 Month)".

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IMPACT OF HIGH MOUNTAINOUS RURAL REGIONS (ILLEGAL DUMPSITES AND LATRINES) OF GEORGIA ON CLIMATE CHANGE

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Abstract

The part of Georgian population living on the rural territory is approximately 46%, and 66% of the territory of Georgia consists of high mountainous regions inhabited by 6.5% of the country's population.

The high mountainous regions of Georgia are characterized by relatively structural weaknesses: non-diversified economy, outmigration, extreme poverty, underdeveloped infrastructure, limited access to health care and other public services such as waste management and sewerage. All these lead to increased formation of illegal dumpsites and latrines, which in turn impact on climate change. The aim of the research was to determine impact of illegal dumpsite and latrines on climate change using IPCC methodology and experimental data about quantity and morphological composition of municipal solid waste and statistical data of amount of latrines in High Mountainous Rural Regions of Georgia.

The results of illegal dumpsites and latrines study shows that methane emissions from illegal dumpsites generated by high-mountainous rural regions of Georgia is 0.01% of emissions from the waste sector, while methane emissions from latrines amount is 0.01% of emissions from all sectors of Georgia.

Key words: High Mountainous Rural Regions, illegal landfills, waste, latrine, climate change.

Introduction

From ancient times up to the 19th century, the entire population of Georgia was mainly inhabited by rural residents. Certainly, there were many cities in Georgia, but the population of the cities was very low, and 3,668 villages were registered in the country. At present, 236 villages have been abandoned in Georgia, there are mostly border villages. Today, 152 villages are inhabited with fewer than 10 people. Especially the population has decreased in the historical high mountain regions of Georgia: Racha, Lechkhumi, Svaneti and Tusheti-Pshavi-Khevsureti. To facilitate the development of high mountainous regions, in spring 2015 the Law of Georgia "On the development of high mountainous regions" has been adopted [1]. On the basis of this Law National Council for the Development of Mountain Regions to work on the development of high mountainous regions of Georgia has been created. Based on the law, it is expected to decline the abandoned villages of high mountain regions. At that, the people living in rural areas have big problems with convenience and infrastructure - unusable roads and the lack of water supply and sewage systems [2].

The absence of infrastructure of road and sewerage network in the high mountain rural regions obstacle to collection/remove of waste and contributes to accumulation of faecal mass.The existing problems with waste management and sewage networks in high mountainous rural areas of Georgia represents a critical danger to human and environmental health.The current practice of waste disposal in rural areas of Georgia implies the disposal of waste on uncontrolled/illegal landfills - in nearby gorges, on roadsides and on river banks without any safety measures and sanitary and environmental standards. Furthermore, along with household waste, industrial, construction, medical, biological, agricultural and other hazardous wastes are dumped at landfills. As a result of unsanitary conditions various infections are spreading that threaten human health, especially during a hot period of the year. The problem is the result of flaw in the system of waste management - collection and transportation of waste [3]. Due to the obstacles of infrastructure, the rules of life and work of residents of high mountainous regions are very specific.

As a result of undeveloped municipal activities and the practical absence of retail facilities, the morphological composition and quantity of waste generated by the population of high mountainous rural regions is very peculiar and, accordingly, greenhouse gas (GHG) emissions from illegal landfills of high mountainous rural regions are substantially different from the average GHG emissions from other landfills of Georgia.

Materials and methods

At the first stage, the purpose of the study was to determine the number and morphological composition of Municipal Solid Waste (MSW) generated by residents of high mountainous rural regions of Georgia.In each region with the purpose of acquisition of statistical information on waste were held meetings with representatives of governances of municipalities. Study of quantity and morphological composition of MSW in Georgian high mountainous villages was carried out with the use of quantitative method of sociological research and gravimetric analysis [4].

Table 1

Dependence of the morphological composition of waste on the degree of urbanization of the regions of Georgia

№	Fraction	Urban	Rural
1	Glass	1.38	1.52
2	Paper	13.80	3.03
3	Metal	1.38	0.00
4	Plastic	1.84	1.36
5	Nappies	2.30	3.03
6	Rubber/Leather/Textile	0.63	0.00
7	Wood/Garden	0.38	0.00
8	Fine Fraction	9.20	75.82
9	Hazardous	0.13	0.08
10	Food	68.98	15.16
11	Total	100	100
12	Amount of Waste kg/cap/year	265	70

The research indicated that the quantity and morphological composition of MSW generaed by population of different municipalities of Georgia, depends to a large extent on the level of urbanization of the regions (Table 1). As folows in (Tab. 1.), the amount of waste generated in villages is 3.8 times less than in cities, which is mainly due to the greater proportion of the fine fraction and the low proportion of food waste.The amount of food waste in rural areas is 4.5 times lower than in cities, which is attributed to the use food waste to livestock. The second phase of the research included the collection of statistical data of the population and the state of the sewer system of tof the high mountainous rural regions of Georgia.

In the absence of integral sewage system in the villages, private latrine are used, which use of which causes damage not only to surface and groundwater (widespread use of groundwater associated with lack of water supply), but also contributes to greenhouse gas emissions into the air and thereby contributing to climate change. The part of Georgian population living on the rural territory is approximately 46%, and 66% of the territory of Georgia consists of high mountainous regions inhabited by 6.5% of the country's population (Tab. 2.).

Table 2

Population according to the degree of urbanizationof the regionsof Georgia

The main demographic indicators									
Years	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total Population	4.4364	4.4692	4.4976	4.4838	4.4905	3.7137	3.7204	3.7182	3.7296
Urban Population	2013.233	2002.201	1988.469	1999.281	1996.231	2127.597	2133.212	2133.279	2135.145
Rural Population	1761.900	1746.829	1726.548	1694.973	1696.520	1570.127	1571.188	1568.873	1570.245
High Mounta-inous Rural Regions Population	24.699	24.528	24.306	24.170	24.160	24.192	24.236	24.221	24.243

Results and discussions

Based on received data of MSW (Tab. 1.), statistical data of the population (Tab. 2.) and the default values of the IPCC methodology [4] the methane emissions were calculated from the waste sector from 2010 to 2020 using the 2006 IPCC methodology [5] (Tab. 3.). Tab. 3 follows, that 2010-2020 average emission of methane is 0.026 Gg, which shows low of methane generation at this regions and there is basically caused by low biodegradable faction of dumped MSW. Also, the aim of the research included determining impactof latrines on climate change using IPCC-2006 methodology, the default values of the IPCC-2006 methodology and statistical data of amount of population in High Mountainous Rural Regions of Georgia.

Table 3

Emission of methane from the waste sector depending on the degree of urbanization of regions of Georgia

Years	CH_4, Gg				%, Mountainous Rural Regions
	High Mountainous Rural Regions	Urban Regions	Rural Regions	Total	
2010	0.0009	21.5779	0.9866	22.5645	0.004
2011	0.0013	21.8593	0.9975	22.8568	0.006
2012	0.0017	22.1188	1.0073	23.1262	0.007
2013	0.0020	22.3559	1.0159	23.3718	0.009
2014	0.0024	22.5887	1.0228	23.6115	0.010
2015	0.0027	22.8078	1.0294	23.8372	0.012
2016	0.0030	23.1074	1.0309	24.1384	0.013
2017	0.0033	23.3958	1.0325	24.4283	0.014
2018	0.0035	23.6697	1.0339	24.7036	0.015
2019	0.0038	23.9311	1.0353	24.9664	0.016
2020	0.0040	24.1794	1.0366	25.2159	0.017
Average					0.011

Georgian population generates average 100 m^3 domestic wastewater as well; according to the IPCC-2006 methodology estimated BOD values in domestic wastewater for our region is 0.4 g/L, whereas the default value of MCF = 0.1 and Bo (carbon share in Gbm) = 0.6, therefore, 40 kg/cap/year (BOD)*0.1(MCF)*0.6(B_0)=2.4 kgof methane per capita per year.Accordinglyduring the year, the average amount of methane generated from latrine in mountainous rural areas is 0.06 Gg, which is 6 times higher than methane emissions from landfills of high mountainous rural areas of Georgia.

Conclusions

The results of illegal dumpsites and latrines study shows that methane emissions from illegal dumpsites generated by high-mountainous rural regions of Georgia is 0.011% of emissions from the waste sector, while methane emissions from latrines amount is 0.01% of emissions from all sectors of Georgia [6].

Acknowledgements

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STUDY OF THE POLLUTION OF RIVERS AND SOILS IN THE ADJACENT AREAS OF MADNEULI IN BOLNISI MUNICIPALITY

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Abstract

The Madneuli factory operating in the Bolnisi municipality is a risk factor for the ecosystems of the region. Environmental chemical contamination is a particular threat to human health - increase of heavy metal content in environmental objects. The first expedition was carried out in February 2019, sampling on the river and artezian waters near Madneuli enterprise and their physical-chemical, hydrochemical and microbiological characteristics were identified. The results are presented in conclusions. The rivers and artezian waters contaminated by various ingredients have been identified. Soil samples were also taken from background and contaminated areas from 0-10 and 10-20 cm depth. The results are presented in conclusions. The rivers and artezian waters contaminated by various ingredients have been identified, as well as soil polluted by heavy metals – copper, zinc, cadmium, chromium and arsenic.

Key words: Pollution, natural waters, heavy metals, soils.

Introduction

Environmental chemical contamination is a significant threat to human health - increase of heavy metals in environmental facilities (natural waters [1, 2], soils [2-5]) and their impact on food products [6, 7]. In the Bolnisi municipality Madneuli ore is represented mainly by three types of ores - gold-copper-colchadian, gold-baritis and gold-quartzite. The land (damaged) by Madneuli Mining Company is about 500 hectares [8], its annual capacity (extraction and recycling) - approximately 2 million tons of manganese. Ore production is carried out by an open career and will be processed by flotation method. Such types of enterprises represent a significant risk factor for the ecosystems of the region. Priority pollutants of Madneuli enterprise are heavy metals.

Depending on the peculiarities of ore, the main technogenic impact comes from the region's hydro net and soils. Bolnisi is one of the most important agricultural regions of Georgia, which supplies the largest part of the country with vegetables, which clearly determines the scope of disaster.

All of this negatively affects the quality of agricultural products of the region and, therefore, the health of people.

Materials and methods

Kvemo Kartli region (Bolnisi municipality), which is one of the main regions of Georgia, makes a significant contribution to the development of agriculture.

Among the many enterprises in the region the largest is polymeric enterprise, by which ecosystems are contaminated with heavy metals. By the water of the rivers of Kazretula, Mashavera and Poladauri the Bolnisi district agricultural lands are irrigated, which leads to further contamination. Therefore, it is important to monitor physical and chemical, microbiological characteristics of the rivers and artesian waters located in the vicinity of the Madneuli processing plant and this is the main purpose of our research.

Field work was conducted on 15th of February of 2019 to solve the set above objectives: water sampling was conducted and pH, Dissolved oxygen, temperature and salinity were determined by the wtw 340. In the laboratory heavy metals Fe, Pb, Cu, Cd, Co, Zn, As, Cr, Ni and Ag were determined, as well as physical - chemical, hydrochemical and microbiological parameters (organoleptic characteristics, biogenic substances, basic ions, mineralization, BOD_5 [9], total coliformes, e-coli and fecal streptococcus) were measured [10]. Soil samples were taken at 0-10 and 10-20 cm depth in which the above mentioned heavy metals were determined [11].

The quarterly expeditions are planned to be implemented to determine precise and reliable parameters according to the seasons. Pollution of surface waters and soils of the Bolnisi municipality in the Kvemo Kartli region will be studied, which will provide us with the information regarding the ecological conditions of the study area.

In particular, it is necessary to determine the rivers (Kazretula, Mashavera, Poladauri) water quality in terms of irrigation of agricultural lands, particularly during the water shortage periods; also, to study the impact of irrigation water and soils on the safety of food products, etc. The water samples will be taken from the rivers Mashavera, Kazretula, Poladiauri and at the source of pollution. The special load comes from the river Kesterula, where the water of the river joins the water from the enterprise. Results of the analysis are shown in the Tab.1.

Results and discussions

The results of conducted analysis have shown that the pH of rivers varies between 7,94-8,18, and within the artezial waters of 7,88-8,01. The reaction shifts toward the alkaline direction. The water pH partly determines the oxidation-restorative potential and the ability to self-purify of the water.

From the cations in the water of the rivers are dominated by Ca^{++}- ions, which are in the ranges: Ca^{++} - 46,78-205,50 relatively small is Na^{+}+ K^{+} - 21,25 - 76,27 and Mg^{++} - ions - 10,81-43.69 mg/l.

From the anion a relatively high content have hydrocarbonates – up to 175,68-247,66 mg/l. The content of chlorine ions varies between 7,10-32,18 mg/l and is less than MPC (maximum permissible Concentrations). Sulfate content is high 46,86-572,30 mg/l. Therefore, mineralization is also high and is -323, 95-968, 24 mg/l.

These waters belong to the waters containing moderate mineralization (500-1000 mg/l). As seen from the results of the analysis, the most polluted river from rivers are Kazretula and Poladauri near the sand-gravel plant.

Tab. 1 presents the list of ingredients in the artesian waters, where it is clearly seen that in artesian waters there is a high content of cations and anions. Therefore, hardness is also high in water (50,57 mg equv./l). The concentration of calcium ion is very high, which is 684.37 and 711,55 mg/l. The Mg^{++} content (195,62, 185,57 mg/l) is also higher, compared to Na^{+}+ K^{+} - 201,25-95,5 mg/l. Sulfate content varies between 2413,81-2416,81 mg/l, which is approximately 5 MPC. According to the mineralization, these waters belong to the high-mineralized (> 1000 mg/l) waters [11]; mineralization ranges from 3698, 44-5022.225 mg/l (Fig.1).

Important components are biogenic elements (nitrogen, phosphorus) that reflect surface water quality pollution and are anthropogenic loading indicators. It is especially important to control the contents of their separate forms (NO2-, NO3-, NH4+, PO43-) in water that characterize the processes such as fecal pollution, eutrophication, discharge of communal and agricultural wastewater in the river, etc.

The obtained results of the analysis indicate that ammonium ions (0,241-1,905 mgN/l) are especially distinguished from the mineral forms of nitrogen in the river waters (NO2-, NO3-, NH4+), with the content exceeding the maximum permissible concentrations in February in about 5 times. The nitrates content is relatively high in Poladauri water (6,377 mgN/l), but in no case does not exceeded MPC (Fig. 2). The phosphate content is also low. The ammonium content in the artezial waters varies from 1,960-3,002 mgN/l to about 8 MPC. Nitride content is very high - 221,54 mgN/l (221 MPC) nitrates and phosphate concentrations does not exceed the appropriate permissible concentrations.

From heavy metals: lead, copper, zinc, nickel, cadmium, iron, arsenic, chromium, cobalt and silver (common form) in water are in the norms except Kazretula, where cadmium content is 0,0018 mg/l (1,8 MPC) and the maximum concentration of iron is 0.7675 (2,5 MPC). In the artesian waters there is an iron increase of 1, 7 MPC. The rest of the heavy metals are within the norm.

The results of microbiological analysis of artificial reservoirs are given in the Tab.1.Pollution changes its physical properties (color, odor, turbidity), chemical composition (organic, biogenic substances, heavy metals, etc.) and microflora.

The high value of coli index shows the fecal pollution rate of water (MPC- 5000 1 dm3). From the results of our analysis, it is clear that in February no water sample was contaminated by microbiological indicators. The exception is the river Kazretula, where chemical pollution is so high that there are no living microorganisms in it. The results of determining heavy metals in soil samples are given in the Tab. 2.

Table 1.

Results of physical-chemical and hydrochemical analyses of studied rivers, 15. 02. 2019

№	Parameters	Mashavera River background	Kazretula River	Kazretula River after joining the Mashavera River	Poladauri River after joining the Mashavera River	Poladauri near sand–gravel factory	Artesian water in a small town of Kazreti	Drinkin g water, village Rachisubani	MPC
1	pH	8,07	8,18	8,04	7,94	8,18	8,01	7,88	6.5-8.5
2	conductivity,sms/cm	372	772	618	552	978	5328	2095	
3	salinity, ppm	0,21	0,38	0,32	0,27	0,50	2,52	0,94	
4	Dissolved oxygen, mg/l	8.73	7.08	7.18	8.57	11.61	6.84	6.19	
5	Dissolved oxygen, %	83	66	65	81	83	64	59	
6	Suspended solids, mg/l	17.6	849.6	76.4	16.4	5.6	130.0	53.0	
7	BOD_5, mg/l	1.47	4.28	0.76	0.85	1.54	2.00	1.64	6.0
8	Hardness mg.equv/l	3,22	13,84	13,29	4,98	7,83	50,22	50,57	
9	Carbonates, mg/l	-	1,8	-	-	2,4	-	-	
10	Carbon dioxide, mg/l	1,41	-	1,76	4,22	-	7,74	6,34	
11	Ammonium, mg/l	0,241	1,905	0,894	0,319	0,303	1,960	3,002	0,39
12	Nitrites, mg/l	0,004	0,382	0,023	0,004	0,005	221,54	0,010	1,0
13	Nitrates, mg/l	3,353	1,075	2,832	4,089	6,377	0,033	2,410	10
14	Phosphates, mg/l	0,195	0,095	0,079	0,027	0,052	0,042	0,036	3,5
15	Sulfates, mg/l	46,86	572,30	267,48	113,90	270,64	2413,81	2416,81	500
16	Chlorides, mg/l	7,10	32,18	16,64	10,39	12,09	133,50	41,63	350
17	Fluorides, mg/l	0,413	0,473	0,492	0,429	0,465	0,010	<0,001	
18	Bromides, mg/l	0,043	0,091	0,066	0,023	0,047	0,882	0,015	
19	Hydrocarbonates, mg/l	175,68	247,66	237,90	204,96	236,68	258,64	236,68	
20	Potassium, mg/l	21,25	76,27	36,25	46,25	50,5	201,25	95,5	
21	Sodium, mg/l								200
22	Calcium, mg/l	46,78	205,50	199,34	68,21	122,08	684,37	711,55	180
23	Magnesium, mg/l	10,81	43,69	40,71	19,16	21,17	195,62	185,57	
24	Silicic acid, mg/l	8,1	7,1	7,5	6,1	9,1	12,2	9,5	
25	Mineralization, mg/l	323,95	768,72	710,94	495,01	968,24	5022,25	3698,44	
26	Lead, mg/l	0,0037	0,0066	0,0038	0,0057	0,0076	0,0048	0,0046	0,03
27	Copper, mg/l	0,0096	0,1997	0,0364	0,0064	0,0014	0,0002	0,0012	1,0
28	Zinc, mg/l	0,0046	0,2479	0,0682	0,0064	0,0012	0,0178	0,0052	1,0
29	Nickel, mg/l	0,0012	0,0036	0,0016	0,0010	0,0021	0,0026	0,0009	0,1
30	Cadmium, mg/l	0,0001	0,0018	0,0004	<0,00004	0,0002	0,0002	<0,00001	0,001
31	Iron, mg/l	0,0206	0,7675	0,5876	0,0339	0,0066	0,0982	0,5064	0,3
32	Arsenic, mg/l	0,0048	0,0084	0,0034	0,0016	0,0065	0,0256	0,0056	0,05
33	Chromium, mg/l	0,0012	0,0008	0,0009	0,0010	0,0017	0,0001	0,0001	0,1
34	Cobalt, mg/l	0,0019	0,0062	0,0014	0,0012	0,0008	0,0042	0,0012	0,1
35	Silver, mg/l	0,0005	0,0006	0,0004	0,0002	0,0001	0,0001	0,0008	0,05
36	Total coliforms, 1 dm^3	3000			2000	1000	3000	1000	
37	E-coli, 1 dm^3	4000			3000	4000	5000	2000	5000
38	Streptococcus faecalis, 1 dm^3	ND			ND	ND	ND	ND	

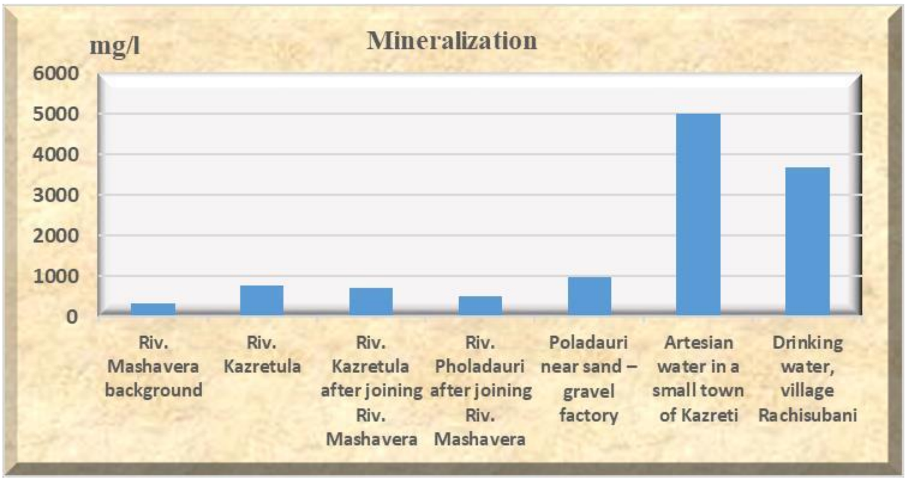

Fig. 1. Mineralization in the waters of the rivers of Mashavera, Kazretula and Poladauri, 15.02.2019

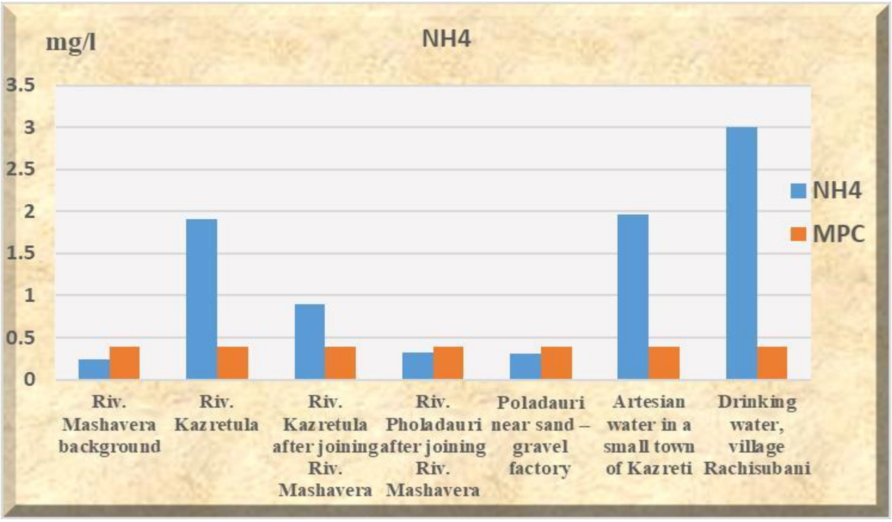

Fig. 2. Ammonium ion-NH_4^+ in the waters of Mashavera, Kazretulaand Poladauri Rivers, 15.02.2019

Table 2.

Heavy metals contents in soil; *-Copper content in Clark [11]

	Moving form of ingredient, mg /kg	The down-stream of the meteorological station (background) 0-10 cm	The down-stream of the meteorological station (background) 10-20 cm	Bolnisi region, village Mukhrana (irrigation) 0-10 cm	Bolnisi region, village Mukhrana (irrigation) 10-20 cm	MPC
1	Iron	1,03	1,15	1,51	1,32	
2	Copper	136,39	138,89	270,29	219,19	47*
3	Zinc	62,31	61,56	322,90	272,80	23
4	Manganese	397,65	415,17	595,44	518,04	700
5	Lead	13,51	5,76	6,01	12,78	32
6	Cadmium	2,75	0,75	3,01	2,25	
7	Cobalt	8,51	9,26	7,77	6,51	5
8	Arsenic	9,76	9,51	8,02	13,28	2
9	Chromium	9,51	7,51	19,79	16,03	6
10	Nickel	14,26	8,01	25,80	28,06	4
11	Silver	10,01	1,75	0,75	0,25	

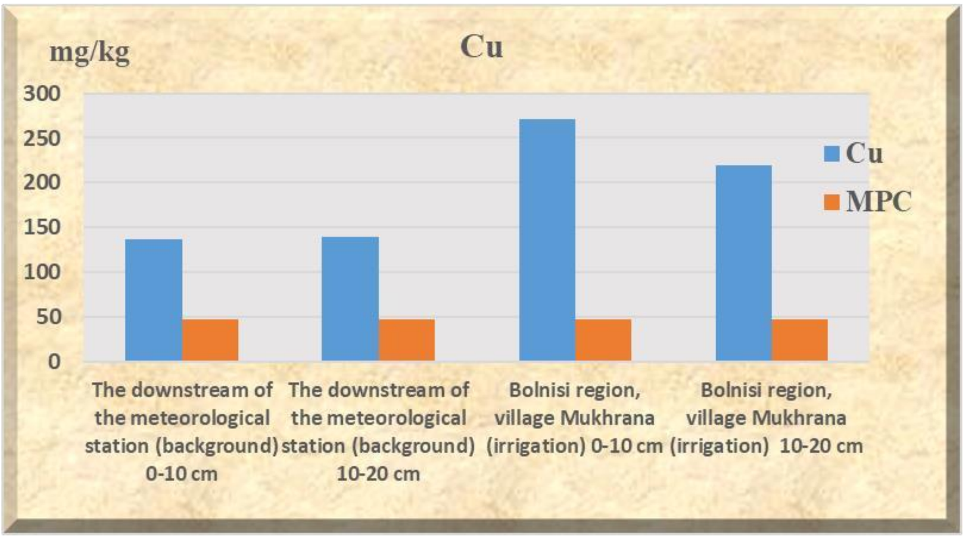

Fig. 3. Copper content in the soil of Bolnisi region

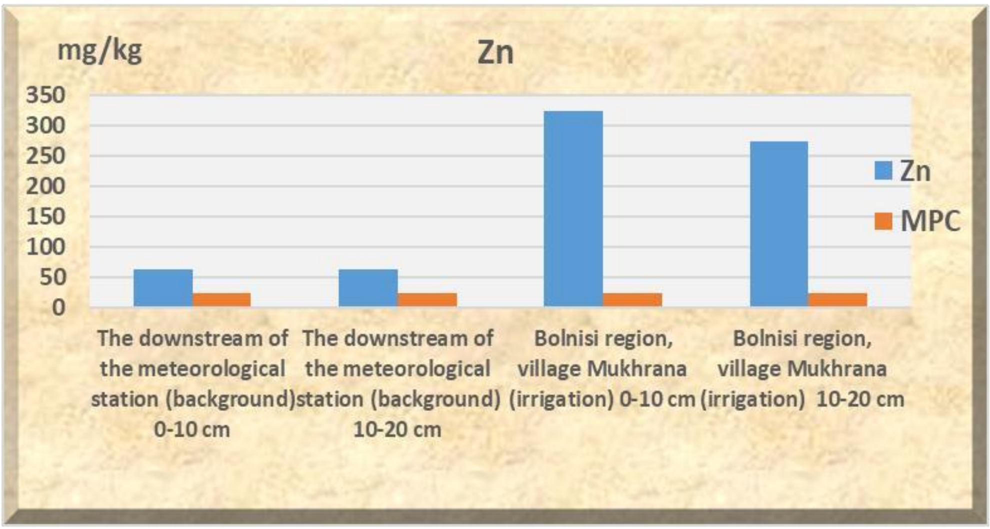

Fig. 4. Zinc content in the soil of Bolnisi region

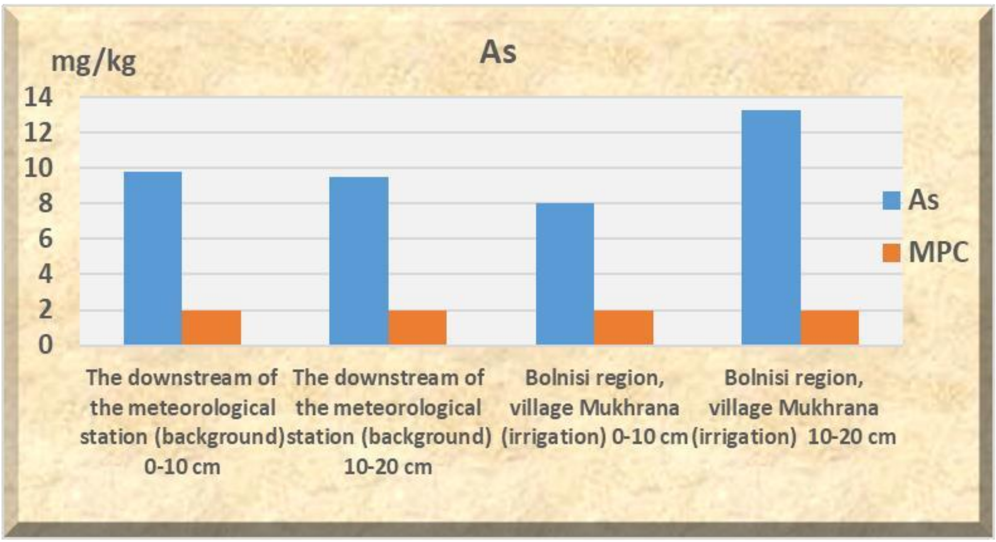

Fig. 5. Arsenic content in the soil of Bolnisi region

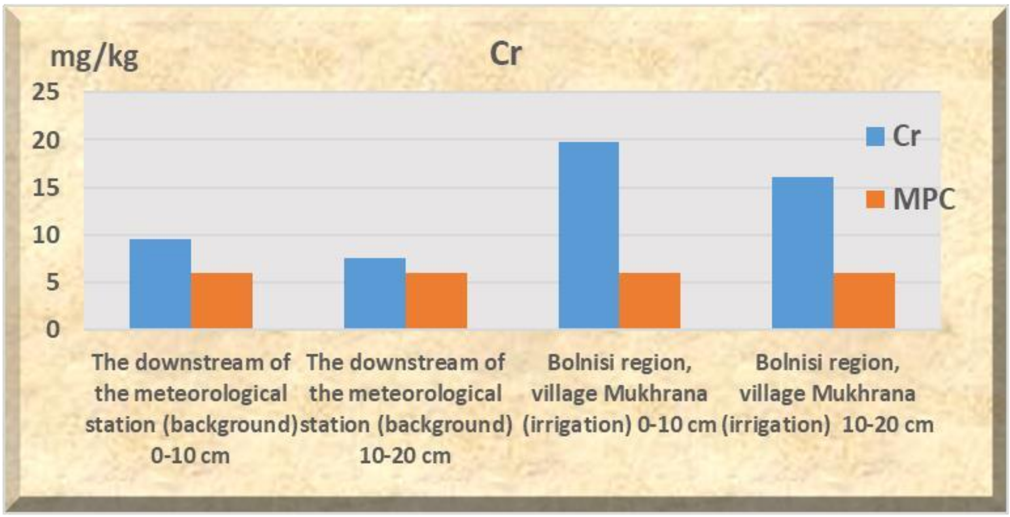

Fig. 6. Chromium content in the soil of Bolnisi region

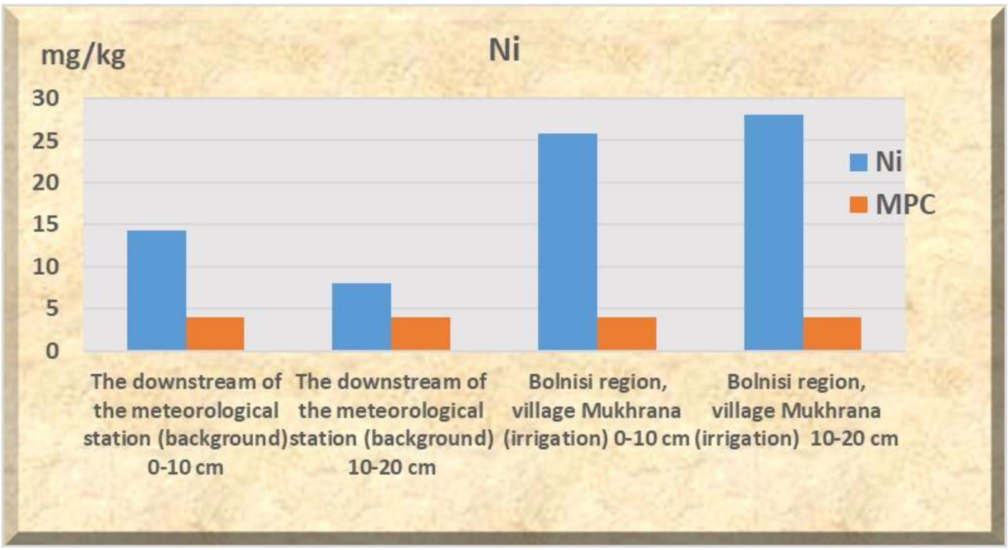

Fig. 7. Nickel content in the soil of Bolnisi region

As the analysis results show, there are copper, zinc, cadmium, chromium and arsenic between pollutant heavy metals. It should be noted that the concentration of metals at a depth of 0-10 cm in most cases exceeds its concentration at 10-20 cm depth. At the same time, there is much higher concentration of metals in the irrigation zone (the village of Mukhrana in Gardabani region), whose territory is irrigated by the river Mashavera water, compared with the background (down from the meteorological plant), which is a natural phenomenon.

If we compare the metals concentration with their average composition and Clark, we get: copper content in Clark 47 and its average content in the soil is 20 mg/kg [11]. As seen from the obtained results, copper content (136,39 mg/kg) in 0-10 cm in the baseline soils exceeds Clark value of 3 times and its average value 6,8 MPC. These values are slightly higher in the 10-20 cm layer.

The copper content in the 0-10 cm layer of irrigation zone (270,29 mg/kg) is higher than Clark's by 5,7 times and 13.5 times its average value. Copper content in the 10-20 cm layer of this zone is slightly less (219,9 mg/kg), etc. Fig. 1 –7 clearly shows all contaminated heavy metal content at 0-10 and 10-20 cm depth.

The researches will be continued in 2019-2020 years as well.

Conclusions

In February of 2010, physical and chemical, hydrochemical and microbiological characteristics of the existing rivers near the Bolnisi Madneuli enterprise were held;

1. The results of the analysis shows that the pH of the rivers varies between 7,94-8,18 and in the artezial waters of 7,88-8,01.
2. Ca^{++}-ions prevailing in the rivers water, respectively: Ca^{++}-46,78-205,50 mg/l, relatively small Na^{+}+K^{+} - 21,25-76,27 and Mg^{++} ions - 10,81 -43.69 mg/l. From the anions there are a relatively high content of hydrocarbonates up to 175,68-247,66 mg/l. The content of chlorine ions varies between 7,10-32,18 mg/l and less then MPC. Sulfate content is high (46,86-572,30 mg/l); The mineralization of rivers is 323,95-968,24 mg/l. These waters belong to the waters with moderate mineralization (500-1000 mg/l);
3. In the artezial waters high content of cation and anion is observed. Concentrations of calcium ions exceeding 684,37 and 711,55 mg/l respectively are high in water (50,57 mg equiv/l). The Mg^{++} content (195,62, 185,57 mg/l) is also higher, compared to Na^{+}+ K^{+} - 201,25-95,5 mg/l. Sulfate content varies between 2413,81-2416,81 mg/l, which is approximately 5 MPC. According to the mineralization, these waters belong to the category of highly mineralized (>1000 mg/l) waters, mineralized is in the range of 3698,44-5022.225 mg/l;
4. In the waters the nitrogen minerals (NO_2^-, NO_3^-, NH_4^+), the ammonium ions (0,241-1,905 mgN/l) are particularly distinguished, with the contents exceeding the permissible concentration of approximately 5 times. The content of the nitrates is relatively high. In Poladauri water (6,377 mgN/l), but in no case does not exceed MPC. Also the phosphate content is low.
5. Ammonium content in artesian waters varies between 1,960-3,002 mgN/l, within about 8 MPC. The nitride content is very high and contains 221,54 mgN/l (221 MPC) nitrite and phosphate concentrations not exceeding the maximum permissible concentrations;
6. Heavy metals: lead, copper, zinc, nickel, cadmium, iron, arsenic, chromium, cobalt, silver content in the river basin are within the norms an exception is river Kazretula where the content of cadmium is 0,0018 mg/l (1,8 MPC) and the maximum concentration of iron is 0.7675 (2,5 MPC). Iron content was 1,7 MPC. The rest of the heavy metals were within the norms;
7. According to the microbiological indicators no pollution was observed. The exception is the river Kazretula, where chemical pollution is so high that there are no living microorganisms in it;
8. As seen from the results, the river Kazretula belongs to the most polluted rivers.
9. Among the heavy metals contaminating soils are copper, zinc, cadmium, chromium and arsenic. It should be noted that the concentration of metals at a depth of 0-10 cm in most cases will exceed its depth of 10-20 cm depth. At the same time there is much higher concentration of metals in the irrigation zone (the village of Mukhrana in Gardabani region), whose territory is irrigated by the river. Mashavera with polluted water, compared with the background (down from the meteorological plant), which is a natural phenomenon.

Acknowledgements

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PHOTO ALBUM

INTERNATIONAL MULTIDISCIPLINARY COMBINED EVENT

„ACTUAL PROBLEMS OF LANDSCAPE SCIENCES: ENVIRONMENT, SOCIETY, POLITICS“

APLS-ENSOPO

September 9-13, 2019, Tbilisi, Georgia

The event objectives:

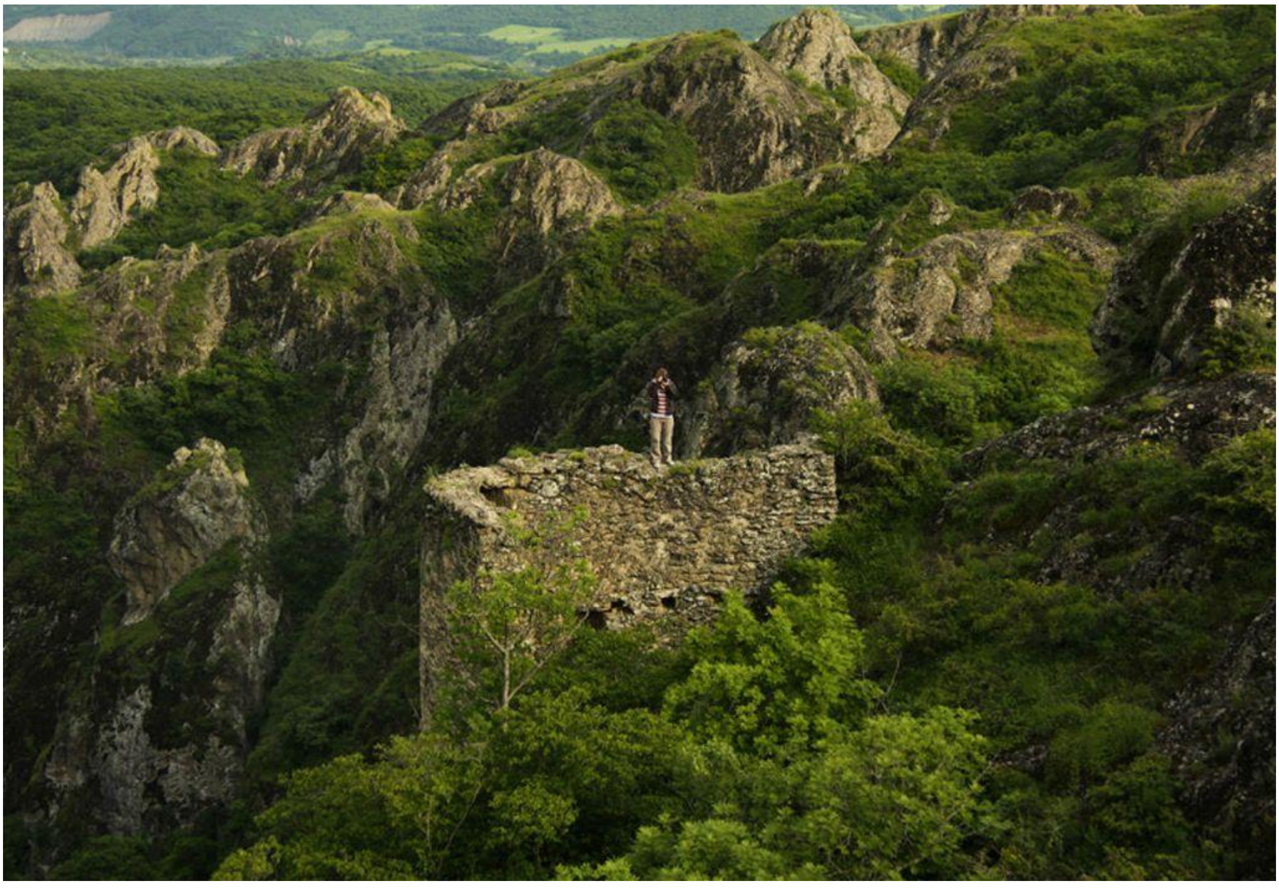
- To promote the dialogue on landscape surveys and exchange/share knowledge and experience; to present achievements of Georgian scientists, their integration into the international scientific sphere and to strengthen the cooperation in order to prioritize future research surveys and develop innovative directions;
- To attract young people to science, represent young researchers, popularize the studies carried out by them and promote their professional growth in order to involve them in future international or local research projects;
- To represent the role of multidisciplinary approaches in landscape studies.

Ritsa Lake – the deepest lake in Georgia (Apkhazeti, Gagra municipality)

Mtsvane Kontskhi (just less than 10 kilometers from Batumi and on the shoreline of the Black Sea)
Photo Credit: Georgian Time

Crystal Lake or Tobavarchkhili, topographic diversity at 2,650 meters above sea level.
Photo Credit: Caucasus Trekking

Shkhara (is at an elevation of 5,193 meters, it is located in the central part of the Greater Caucasus in the Svaneti region) Photo Credit: Caucasus Trekking

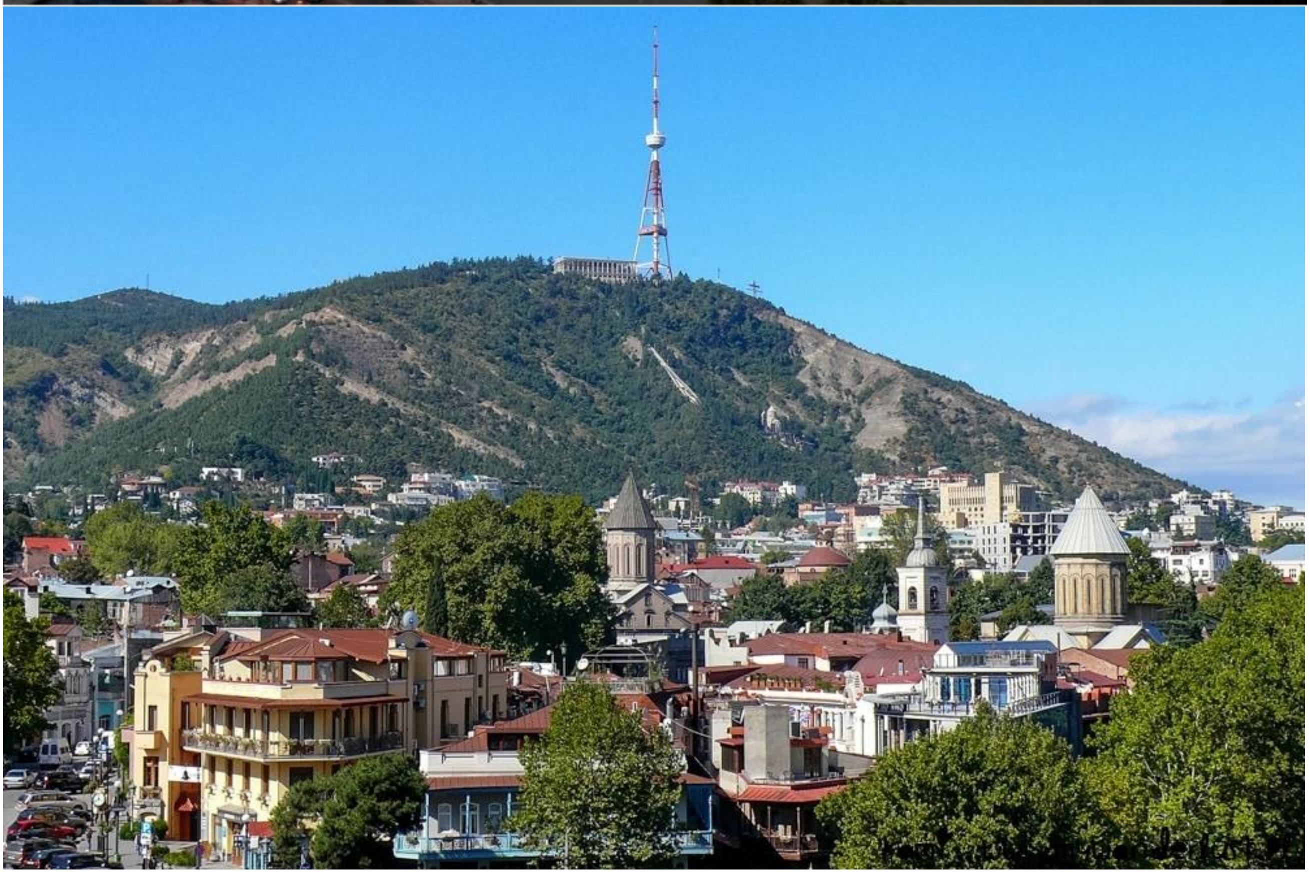


Birtvisi - is a natural rocky medieval fortress surrounded by rocks, south of the capital of Georgia. It can control the entire Algeti gorge. Photo Credit: Georgian Tour

Svaneti. Unique landscape, with stone towers (the towers date back to the medieval times)
By Libby Ryan

Gergeti.Tsminda Sameba 14th century church

Kazbegi and Gergeti. Photo by maykal/Flickr



Tbilisi, capital of Georgia

The project was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG)
Grant MG-ISE-18-370

NUMERICAL MODELING OF CONVECTIVE DUST DISSIPATION INTO THE ATMOSPHERE EMITTED FROM TWO STATIONARY SOURCES

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Abstract

The numerical model of dust propagation emitted into the atmosphere is developed on the basis of three-dimensional non-linear non-quasistatic equation of thermal convection in the atmosphere. F.Shuman's explicit numerical scheme and implicit numerical scheme of splitting according to processes and coordinates, developed by G. Marchuk, are used for equations integration. The model is implemented on the numerical grid with high resolution ability.

The distribution kinematics of 10 μ size dust particles emitted into the atmosphere from two high sources is studied using the numerical modelling. Two meteorological situations – calm air and background north-west wind are considered.

It is obtained by means of modelling that the distribution kinematics of dust emitted into the atmosphere substantially differs from each other in cases of calm air and background motions. Spatial dust distribution occurs as a result of both ordered horizontal and vertical streams, and small-scale whirling and diffusive motions. Advective, convective and turbulent dust diffusion under the influence of background motions forms a vertical inclined fume-like zone of dust pollution. There is no whirling motion in the obtained zone.

Key words: Atmosphere dust, numerical modelling, stationary sources, convective diffusion.

Introduction

The atmospheric air anthropogenic pollution modeling in the industrial centers and study of peculiarities of its spatial and temporal distribution is one of the topical problems of human health and environmental protection. There are lots of polluting agents, and their origination sources [1], transformation kinematics and propagation dynamics [2] are diverse. Respectively, the mathematical models describing the wide range of issues, from local to global scale processes [3-5] are also multifarious. Polluting ingredients' propagation from separate sources to the local scale territory is one of the research directions. Mathematical models describing local propagation of ingredients either use semi-empirical methods [6], stationary and non-stationary Gauss models or rely on the numerical integration of Navier-Stokes non-stationary non-linear non-static equations on the high-resolution numerical grids [7].

The goal of the presented work is to develop on the basis of thermal convection equation, the numerical model of transfer-diffusion of agents emitted from separate source on the grid with high resolution ability (1100 m) and to study by means of this model the local peculiarities of the dust propagation orderly emitted into the atmosphere.

Materials and methods

The system of hydro-thermodynamics equations describing the propagation of meso-scale (≈ 1 km) atmospheric processes and agents emitted from the separate source into the dry atmosphere is used for calculations [8, 9]. Equation system is obtained with an assumption that background wind velocities satisfy the equations of geostrophic wind and we can neglect in the first approximation their horizontal and vertical changes in the local area $\tilde{u} = \text{const}, \tilde{v} = \text{const}, \tilde{w} = 0$. The system is defined in the time interval $0 \le t \le T$ and in spatial area $\omega\{0 \le x \le X, 0 \le y \le Y, 0 \le z \le Z\}$. The equation system is implemented on the numerical grid consisting of 81x81x51 points by using F.Shuman's explicit and G. Marchuk's implicit numerical schemes [9, 10]. Grid steps along the x and y axes are 20 m, along z axis – 10m, time step equals to 0.2 s. Integrating area sizes are 1600x1600x500m. The disordered emission of aerosols during modeling process is not considered. 10μ is taken as the aerosols size. Their sedimentation rate is $w_c = 0.01$ m/s.

The diffusion of dust emitted from two separate sources is modeled. Main characteristic values of emission are given in Tab. 1.

Table 1.

Main characteristic parameters of dust emitted into the atmosphere and sources

No.	Height, H (m)	Area, S (m^2)	Temperature of gas-dust mixture T'_0(^oC)	Emission rate, W_0 (m/s)	Concentration, C_0 (mg/$m^{3)}$
Source No. 1	22	110	50^OC	1	1.8
Source No. 2	42	440	31-63	1	5.4

Results and discussions

The kinematics of dust emitted into the atmosphere from two main sources of ordered emission (source No. 1 and No. 2) is studied by means of the numerical experiment. Modeling is conducted for two meteorological situations: calm air and north-west wind, when the wind velocity increases from 0 to 10 m/s, at 500 m height from the earth surface. In case of this wind direction takes place the dust propagation emitted from both sources along one line and overlapping of their concentrations. Numerical modeling is carried out from the beginning of dust emission into the atmosphere to the establishment of quazistationary distribution – approx. during 0.5 h.

Experiment 1. In Fig. 1 and 2 there is shown the spatial distribution of dust concentration obtained through calculation in case of background calm air, when the main mechanism of dust propagation is presented by thermal convection. Concentration isolines are shown in units of the maximum permissible concentration (MPC = 0.5 mg/m^3). It is seen from these figures that after emission from gas-pollution control equipment the dust is propagated in the atmosphere in the form of two vertical cylindric streams independent from each other. The main dust mass (with concentration >0,1 MPC) is distributed within a thin area, which is getting wider and joins together approx. at 200-350 m height. The angle of cylindric column expansion varies from 5 to 45 grad. At the upper levels a dust pollution cloud is of “mushroom”-like form that is caused by origination of vertical whirl in the convection process.

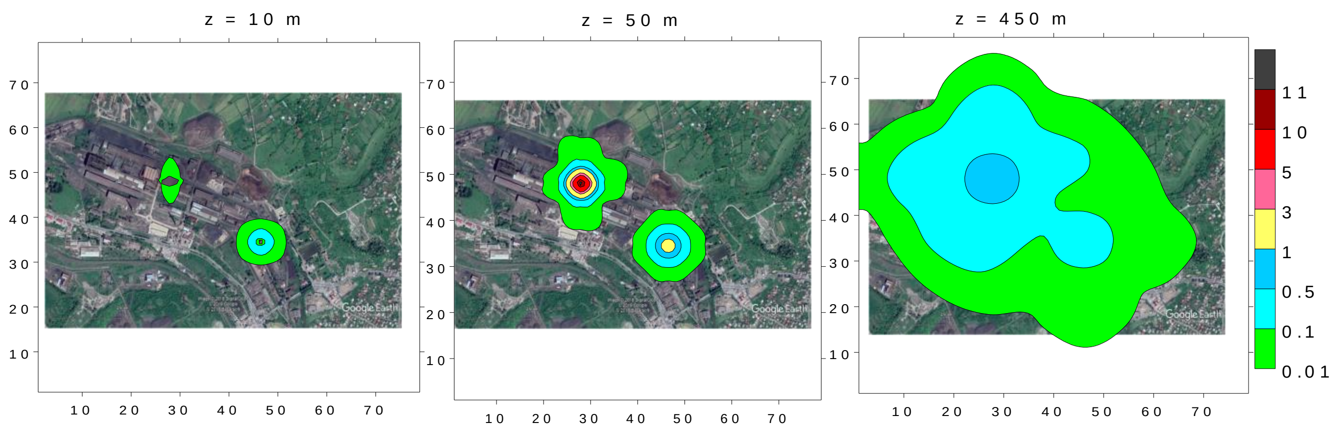

Fig.1. Dust concentration isolines in the atmosphere in case of calm air at 10, 50 and 450 meters height

Concentration > 3MPC is obtained directly above the emission place in the 100-meter column. Concentration value 0,01-0,1 MPC is obtained at the considerable part of the modeling area, at 10, 50m and more height. Close to the earth surface, within 10 meters, the low dust concentration 0,5-0,01 MPC is obtained around the treatment facilities of the source No. 1. Relatively high dust concentration in vicinity of the treatment facilities of the source No. 2 is obtained at considerably smaller area. The spatial pattern of concentration obtained through calculations is formed by the velocity distribution peculiar for thermal convection (Fig. 2 and 3).

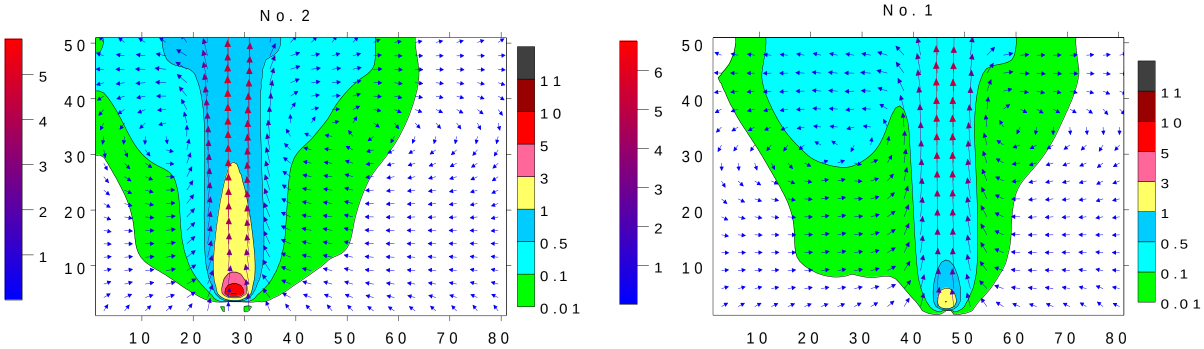

Fig.2. Projections of dust concentration isolines and wind velocity vector on the plane XOZ passing through htreatment facilities

It is seen from the figures that an emitted warm dust mass causes the development of thermal convection. Formation of the strong vertical stream is peculiar for it. Clearly defined convergence area is formed in the 350 meter thick stream layer, and intensification of vertical motion and dust transfer to the upper layer takes place. Above 350 meters the convergent air flow gradually transforms into divergent one, the vertical velocity decreases, wind is increased in the horizontal direction and the process of dust horizontal diffusion becomes more intensive. In the middle part of the modeling horizontal and vertical whirls of wind velocity are formed, unity of which creates a complicated picture of spatial annular stream. Maximum value of wind velocity 6 m/s is obtained in the vertical convective stream.

Motion kinematics shows that dust propagation in the central part of the modeling area occurs as a result of convective, advective, whirl processes and turbulent diffusion. The share of convective transfer and vertical turbulent diffusion in the vertical plane is roughly equal. In the horizontal plane a whirl turbulent diffusion prevails compared to advective transfer.

Gas emitted from treatment facilities changes the atmosphere temperature in the vertical cylindrical area located near the source (Fig. 4). Temperature change is minimal close to the earth and maximal in vicinity of aeration lanterns. Warm air column goes all the way through the space up to its upper limit. At the 450 m height the maximum value of temperature perturbation reaches 5°C.

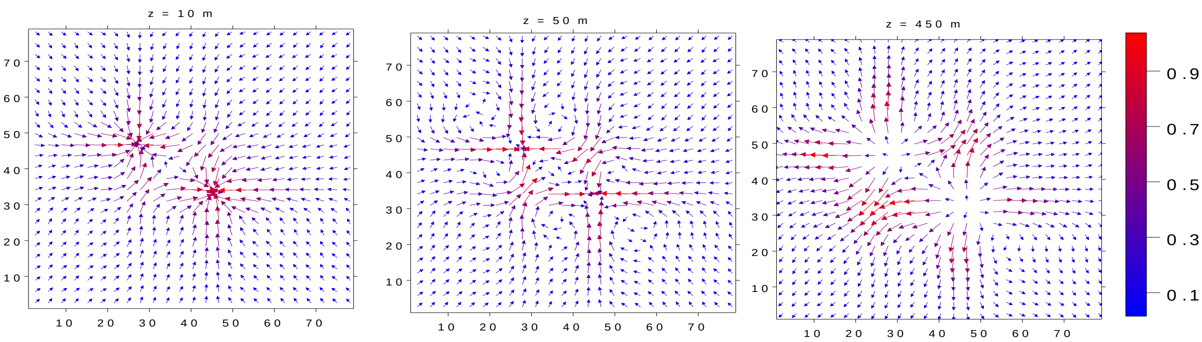

Fig. 3. Horizontal component of wind velocity at 10, 50 and 450 m height

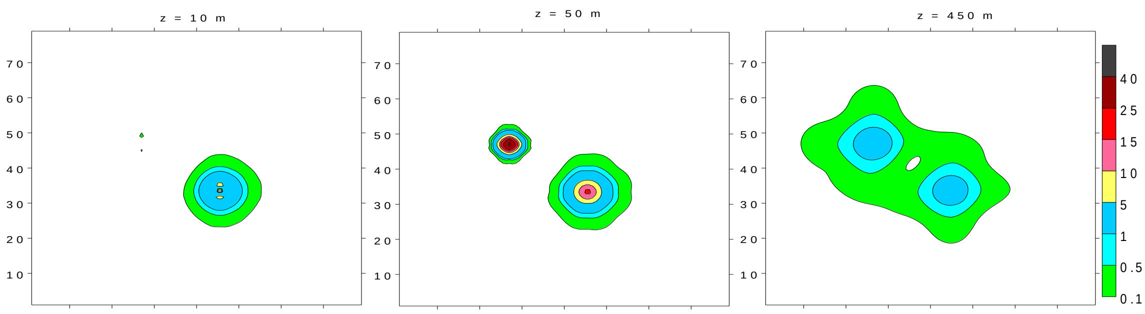

Fig.4. Temperature perturbation field formed resulting from convection at 10, 50 and 450 m height

Experiment 2. Dust propagation emitted into the atmosphere from source No. 1 and No. 2 of the plant in case of north-west wind is modeled. In Fig. 5 and 6 there is shown dust concentration distribution at 10, 50 and 450 m height. It is seen from figures that a dust is transferred in the south-east direction. Along with transfer the dust stream is expanded in the width and takes different forms. Close to the earth surface the dust pollution zone is located in vicinity of aeration lanterns. Concentration value is small there and varies within the limits of 0,01-0,5 MPC. Approx. at 300 m distance from emission place at 450 m height concentration reaches 0,5 MPC. At 50m height a pollution cloud is of rectangle-like form. Concentration maximums are located directly in the neighborhood of emission places and decrease in both towards background wind and its perpendicular direction. The pattern which differs from the classic dust propagation is obtained in the central part of its stream at 50 m height, where the total concentration value created by both sources is equal to zero. The obtained effect is caused by local ascending motion formed during dust convective transfer (Fig. 6 and 7). It is seen from Fig. 6 and 7 that the development of thermal convection accompanied by hot gas-dust mass emission into the atmosphere forms the horizontal convergence zone of wind velocity (Fig. 7) and powerful ascending motion at the leeward side of the emission (Fig. 6). The ascending motion velocity considerably increases the dust particles deposition rate. As a result, at more than 30 meter distances from the source the convective dust transfer to the upper levels prevails gravitation and turbulent deposition and reduces dust pollution near the ground. In case of two sources, the combined action of two convective cells amplifies the convective transfer effect and reduces dust deposition on the underlying

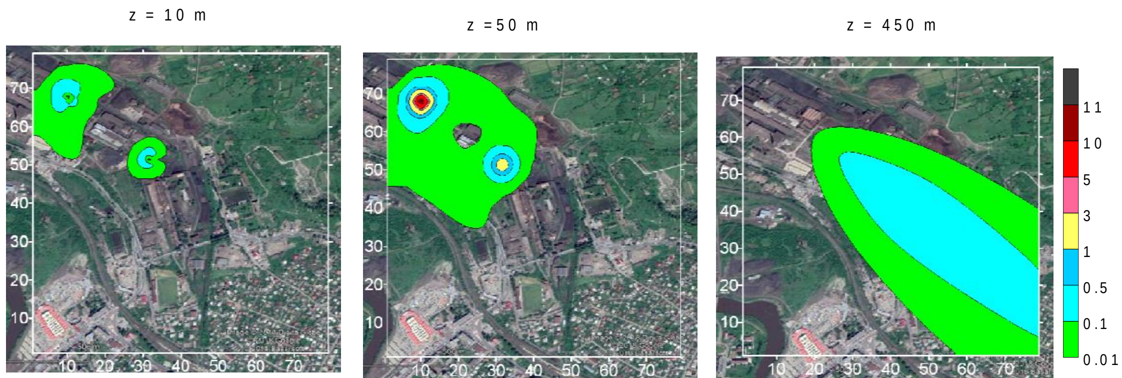

Fig.5. Dust concentration isolines in the atmosphere in case of north-west wind at 10, 50 and 450 m height

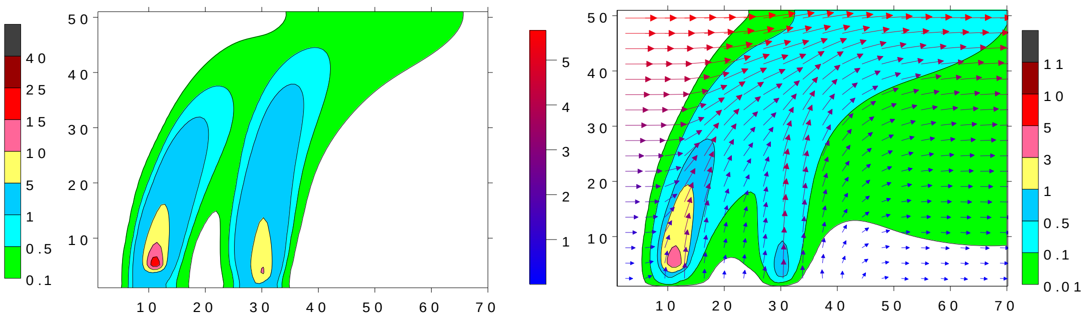

Fig.6. Distribution of temperature perturbation and dust concentration isolines and wind velocity vector in the vertical cross-section (directed along the background wind) that passes aeration lanterns of source No. 1 and No. 2

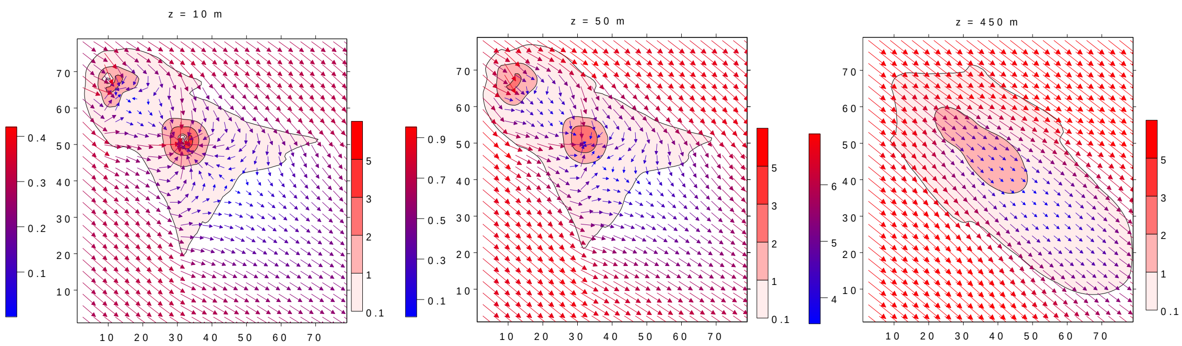

Fig.7. Distribution of wind velocity vertical component isolines and horizontal components at 10, 50 and 450 m height

surface. As a result close to the earth the area with small dust concentration is obtained. In the upper layers a barocline wind and established convective motions cause arc-like transfer of dust in the vertical plane in the direction of background motion.

In case of the background wind, in contradistinction from the calm air, horizontal and vertical whirls of local scale don't initiate. Respectively a turbulent whirl diffusion of dust doesn't take place. Transfer is conducted as a result of convective and advective motions and gradient turbulent diffusion.

Conclusions

The conducted numerical experiments have displayed some peculiarities of local dust transfer that are not derived by means of wide-spread meso-scale and quazistatic models [2, 11]. In particular, they showed that the thermal convection dynamics acts opposite to turbulent diffusion and sedimentation processes, considerably reduces dust concentration in vicinity of the source close to underlying atmospheric surface. In the neighborhood of emission source takes place dust transfer from lower levels to the higher levels and their consequent advective propagation. Close to the source and in the lower 300 m layer, in case of warm emissions and calm air situations the vertical dust transfer is prevalent, while in the upper part – advective and turbulent transfer caused by divergent motion. During background barocline wind the dust concentration in the atmospheric surface layer is higher than in case of background calm air. The mentioned effect is presumably caused by the increase in vertical turbulence transfer related to barocline motion.

It should be noted that calculation results are in qualitative agreement with the common results obtained through observation [12] for emitted industrial ingredients.

Acknowledgments

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SESSION 4. LANDSCAPE DYNAMICS, CLIMATE CHANGES AND EXTREME PROCESSES IN ENVIRONMENT

IMPACT OF WEATHER AND CLIMATE EXTREMES ON LANDSCAPES IN GEORGIA

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Abstract

Landscapes are dynamic and subject to continuous change. Global climatic variations are the main drivers and controls of these processes. Extreme events matter around the whole globe. Hazards related to environmental change include floods, drought, heatwaves, storms and others. They have devastating effects for local populations; others have largerscale impacts via economic and cultural dependencies. Precipitation extremes are leading worldwide to disastrous landslides and floods. Understanding landscape change requires a better recognition of the driving forces. To understand the effects of climate change on biodiversity and human society, it must be taken into account both climaterelated changes in the abiotic environment, effects of other drivers such as land use, potential interactions and etc.The frequency and intensity of extreme weather events rises. Aim of European Landscape Convention is to achieve sustainable development based on a balanced and harmonious relationship between social needs, economic activity and the environment.

For the better understanding of the impact of weather and climatic extremes on landscape transformation long-term (1970-2017) meteorological observation data have been used. It includes extreme temperature, precipitation and wind data evaluation. The results were used for agroclimatic zoning of Georgia's territory and recommendations for adaptation and mitigation measures.

Key words: Weather and climate extremes, landscape transformation, disastrous events, European Landscape Convention, adaptation and mitigation measures.

Introduction

European Landscape Convention defined-"Landscape" means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" and established aims, measures and responsibilities for each party to be undertaken [1].

The Intergovernmental Panel on Climate Change has documented and summarized the "unequivocal" evidence for climate change, incorporating information in their analysis from thousands of datasets spanning timescales of decades to millennia (IPCC 2007). Although the nature and severity of future climate change at subregional scales remains uncertain, there is enough information to assess the vulnerability of species and ecosystems within range of potential future climates. The vulnerability is defined as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" and recognize that a system's vulnerability is related to the character, magnitude, and rate of climate change and variation that it is exposed to, as well as the system's sensitivity and capacity to adapt (IPCC 2007) [2].

Climate change may relieve some stressors, while exacerbating others. Warmer temperatures and shifting precipitation patterns are expected to strongly influence ecosystem drivers. Annual increases in temperature represent thebroadest possible stressor, strongly influencing other stressors and ecosystem responses.Earlier spring thaws and later first frosts in autumn could result in greater growth and productivity, but only if there is enough water.Annual precipitation may increase, but a greater proportion of precipitation may occur during winter, leaving longer, drier summers. Changing rainfall patterns and increased evapotranspiration are expected to decrease soil moisture.

The frequency, size, and severity of natural disasters will change across the whole globe.Wind storms, ice storms, droughts, wildfires, and floods are likely to cause greater damage. Forest ecosystems will continue to adapt to changing conditions. As species distributions change, communities may fundamentally change or even disaggregate as increased stress, disturbance, and competition from nonnative species alter competitive dynamics.

Changes in hydrology, disasters, and other stressors may combine to reduce growth rates, vigor, and health of many important species. Certain species, communities, and ecosystems may be particularly vulnerable to severe declines in abundance or may be lost entirely from the landscape.

Management practices have always had an important influence on forest composition, structure, and function, and will continue to influence the way that forests respond to climate change. Management practices will continue to shape forests by influencing forest composition, species movement, and succession trajectories. Many commercially and economically important tree species may face increased stress and lowered productivity, which may affect the availability for some products. Impacts of climate change will increase the human and capital resources needed to assist regeneration of native species, control wildfires, combat invasive species, and cope with pests and diseases [3].

Landscapes are dynamic and subject to continuous change. Large-scale processes, such as denudation, sedimentation, shoreline displacement and natural succession biotic are interrupted locally by small-scale and short-term disturbances, such as fire, land use, erosion and flooding. Global climatic variations are the main drivers of, or controls on, many of these processes. Understanding landscape change requires a better recognition of the underlying causes, called driving forces, keystone processes or drivers of landscape change. The ways climate change drives landscape transformation are manifold. Three impacts of climate change on landscapes are identified: (1) the direct effects of natural agents, such as heat waves, floods, droughts, storms, and altered habitats; (2) adaptation measures to adjust socio-economic and biophysical systems to changing conditions; (3) mitigation measures to limit the degree of future warming by curbing greenhouse gases.

Weather extremes may have strong effects on biodiversity, as known from theoretical and modeling studies. Predicted negative effects of increased weather variation to understand how we can adapt landscapes to facilitate species persistence, we need to investigate how climate change impacts interfere with population dynamics at the regional scale . In this paper, we focus on a relatively unknown aspect of environmental stochasticity: extreme weather events related to climate change. At a global scale climate models project more intense hot extremes, less intense cold extremes, more intense precipitation and longer dry spells, although at a local scale there are many uncertainties in the projections of climate models. To understand the effects of climate change on biodiversity and human society, as well as the responses of society, the scientific community must take into account both climate-related changes in the abiotic environment, effects of other drivers such as land use, and potential interactions and synergies between drivers [4]. Climate change is a threat to people and the ecosystem services on which we depend. Extreme weather events are on the rise. Flooding, drought, and wildfires are more frequent and more severe. Higher temperatures are increasing community health risks. The changing climate is causing species dislocation and accelerating the rate of species extinction. Global agricultural systems are increasingly stressed. These early effects are harbingers of the more severe consequences that science tells us we can expect in the future if we do not act.

Extreme events matter around the whole globe. Hazards related to environmental change include floods, drought, heatwaves, storms and others. Some of the hazards have devastating effects for local populations; others may even have larger-scale impacts via economic and cultural dependencies. Precipitation extremes are leading worldwide to disastrous landslides and/or floods; cascading risks might be quite straight forward for some examples, but are less clear when societal mechanisms are involved.

Over the last 200 years, the development of newly introduced anthropogenic activities have played a major role in changing the dynamics of our world.2 These human activities have had various impacts on earth systems, such as the atmosphere, hydrology, biosphere and geosphere, by modifying earth system processes, interactions and landscapes. By modifying the landscape and atmosphere, anthropogenic activities lead to changes in hydrological characteristics which have exacerbated flooding in the world today.3 Human activities alter the landscape through urbanization, industrial development, changes in agricultural practices and intensity. Factors influencing flooding in urban and rural areas differ. Development of technology in this era encourages innovation of agricultural practices and expansion of industries which alter the composition of earth’s atmosphere and natural landscape. The modification of climatic patterns by anthropogenic activities, such as industrialization, increases greenhouse gases concentration in the atmosphere.4 Global carbon dioxide, in particular, rose tremendously from 275 parts per million (ppm) to 380ppm between the year 1750 and 2000.5 In turn, this influences temporal and spatial variability in the isotopic composition of rainfall, enhancing inundation in an area [5,6]. Climate change threatens global biodiversity, ecosystem function, and human systems [2]. Already, observed impacts of climate change on species range from changes in phenology to local extirpations. Even if greenhouse gas emissions are held at year 2000 levels today, the history of past greenhouse gas emissions will contribute to unavoidable warming in the future. Instead, recent emissions rates continue to rise above the highest greenhouse gas emissions scenario utilized by the Intergovernmental Panel on Climate Change (IPCC) for global assessments[2]. To prevent catastrophic loss of biodiversity, conservationists must not only find ways to curtail greenhouse gas emissions, but also help species adapt to a changing and more variable future climate through targeted implementation of conservation strategies such as protecting land, restoring habitat, encouraging compatible lands uses, and reducing fragmentation

Materials and methods

The Georgian relief may be characterized by three sharply expressed orographic elements: in north Caucasus, in south – Georgian south uplands and lowland or intermountain depression located between those two risings. This one begins from The Black Sea shore by triangular Kolkheti Lowland and spreads up to eastern Georgia like narrow strip. Between those two uplands small scaled orographic elements can be allocated. Such complicated relief has definite influence on air masses motion in atmosphere lower layers. Mainly west and eastern atmospheric processes prevailed over Georgian territory.

Due to complex orographic conditions and influence of the black Sea in Georgia exist most of Earths climatic types, from marine wet subtropical climate in west Georgia and steppe continental climate in east Georgia up to eternal snow and glaciers in high mountain zone of Great Caucasus, and also approximately 40% of observed landscapes. Current geodynamics and orographic properties of Georgia play an important role in formation of weather various patterns. Such complex relief conditions the formation and evolution of various scaled circulation systems and heterogeneous spatial distribution of meteorological elements. This is verified by the fact, that precipitation annual distribution has diverse type, with sharply expressed spatial inhomogeneities. The local circulation systems developed on the background of synoptical processes play significant role in the spatial-temporal distribution of weather determining parameters. To conduct investigation 1956-2015 daily temperature and precipitation meteorological station data of west and east Georgia were used. Tab.1 presents the event number occurred during used period when temperature exceeded 20, 25, 30 and 35^0C.

Table 1.

The event number occurred during 1956-2015 period when temperature exceeded 20, 25, 30 and 35^0C

Station	T_{max20}	T_{max25}	T_{max30}	T_{max35}
Batumi	9669	4224	330	32
Gori	9364	5461	1619	88
Gurjaani	8630	5663	2162	182
Khulo	8193	3636	768	75
Khvareli	8576	5613	2216	206
Lagodekhi	10383	6992	2964	417
Poti	10021	5330	811	69
Qobuleti	10187	4976	587	74
Qutaisi	11435	7339	2405	401
Sagarejo	8869	5172	1476	61
Samtredia	9641	6322	1992	216
Tbilisi	10461	7141	3264	439
Telavi	9681	5966	2038	158
Zestaphoni	11016	7469	3047	584
Zugdidi	10808	6448	1594	183

Table 2.

The event number occurred during 1956-2015 period, when precipitation amount exceeded 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80 and 90mm..

Station	P_{15mm}	P_{20mm}	P_{30mm}	P_{35mm}	P_{40mm}	P_{45mm}	P_{50mm}	P_{55mm}	P_{60mm}	P_{70mm}	P_{75mm}	P_{80mm}	P_{90mm}
Batumi	3048	2406	1485	1190	956	772	616	485	385	243	190	147	99
Gori	407	204	52	27	16	9	5	3	2	2	2	1	0
Gurjaani	734	483	201	132	92	61	40	28	20	7	6	6	2
Khulo	1628	1074	522	383	276	192	130	90	65	29	22	19	8
Khvareli	950	602	292	200	145	107	85	60	43	19	15	14	4
Lagodekhi	1343	914	426	310	233	171	124	101	84	47	38	30	15
Poti	2294	1664	926	709	556	434	352	279	234	172	140	115	84
Qobuleti	3126	2408	1401	1088	867	674	546	446	369	246	203	161	107
Qutaisi	1838	1240	531	361	257	176	122	80	58	33	26	20	8
Sagarejo	796	485	205	122	86	65	44	29	16	11	7	5	1
Samtredia	1622	1099	531	369	258	187	133	97	69	36	26	20	10
Tbilisi	450	265	96	59	43	34	28	23	15	10	8	6	5
Telavi	848	525	219	146	102	76	56	39	24	16	11	9	5
Zestaphoni	1484	912	397	275	188	120	78	52	36	16	9	5	1
Zugdidi	2339	1639	875	643	486	384	289	231	189	114	91	76	57

Forest landscapes are most vulnerable ecosystems all over the world. About 500 billion tons of carbons are stored in vegetation worldwide. Deforestation and forest degradation alone accounts for 17.4% of the world's greenhouse gas emissions [7]. The deforestation causes include many factors. The destruction of the forests is occurring due to various reasons, one of the main reasons being the short-term economic benefits. Given below are some more common causes of deforestation: Urban Construction; Agriculture; Grazing; Land Used for Fuel; Commercial Purposes; Some of the other causes of deforestation are: clearing forests for oil and mining exploitation, to make highways and roads, Wildfires, and acid rain. Forest fires can occur naturally or in most cases are deliberate attempts by man to clear huge forests. Most of the time, these forests may recover, but usually the cleared land is used for construction and agriculture purposes. This leads to loss of forests and loss of habitat for the local wildlife [8].

The most applicable product from satellite observation is Normalized Difference Vegetation Index that is used in observation on vegetation. The Normalized Difference Vegetation Index (NDVI) is an index of plant “greenness” or photosynthetic activity, and is one of the most commonly used vegetation indices. Vegetation indices are based on the observation that different surfaces reflect different types of light differently. Photosynthetically active vegetation, in particular, absorbs most of the red light that hits it while reflecting much of the near infrared light. Vegetation that is dead or stressed reflects more red light near and less infrared light.Vegetationindexes are important ecosystem variables widely used in variety of biogeophysical applications. The Vegetation Health Product (VHP) consists of gridded weekly global vegetation indices (VCI, TCI and VHI) derived from AVHRR GAC orbital data for the global area. The Green Vegetation Fraction (GVF) system was developed to generate GVF as a NOAA-Unique Product (NUP) from data from the Visible Infrared Imager Radiometer Suite (VIIRS) sensor onboard Suomi National Polar-orbiting Partnership (SNPP) satellite, for applications in numerical weather and seasonal climate prediction models. GVF will be produced as the daily rolling weekly composite at 4-km resolution (global scale) and 1-km resolution (regional scale) [9]. For Georgian territory NDVI varies within 0.5-0.2 range; Green Vegetation Fraction (GVF) - 84.0-72.0-60.0; Fractional Vegetation (FV)-0.7-0.25 [10].

Due to the climatic, orographic and other conditions on the territory of west Georgia, the distribution of agroclimatic resources is different. Efficient use of agroclimatic resources is of a particular importance to make farming profitable. Successful farming basically depends on the rational distribution of the agricultural crops in the specific area by considering their demands to agroclimatic conditions. Based on the data of 60year-long meteorological observations, depending on the sum of active temperatures (>10°C) and atmospheric precipitations (mm), for the 6 regions in West Georgia, the following agroclimatic zones were identified based on vertical zoning, in particular, 6 agroclimatic zones for Samegrelo-Zemo Svaneti, 5 agroclimatic zones for Guria, 5 agroclimatic zones for Imereti, 4 agroclimatic zones for Racha-Lechkhumi-Zemo Svaneti, 6 agroclimatic zones for Achara [11]. By considering the given zones, it is possible to develop branches of agriculture (grain-growing, tea-growing, citrus-growing, vine-growing, fruit-growing, vegetablegrowing, potato-growing, cattle-breeding, etc.).

For eastern Georgia [12,13] the following agroclimatic characteristics were used: air temperature sum, precipitation sum and frostless period. These characters are presented in Table 3.

Table 3.

Some agroclimatic characteristics of Kakheti region for warm period (IV-X)

Station	Air temperature sum (≥10°)	Precipitation sum (mm)	Frostless period (day)
Sagarejo	3420	550	222
Dedoplistskaro	3230	490	209
Telavi	3730	590	233
Gurjaani	3920	540	245
Kvareli	3960	760	239
Lagodekhi	3980	740	242

In east Georgia there were selected V agroclimatic zones.

Discussion

Many researchers have developed frameworks for vulnerability assessments for general systems and for species [14]. Based on these frameworks, we have produced a generalized representation of the vulnerability assessment framework for species. Species vulnerability is a function of climate change related impacts and the adaptive capacity of the species.

Impacts are a combination of exposure and sensitivity to climate change, but can be mitigated by microhabitats and topographic buffering. Exposure is driven by regional changes in climate, while sensitivity is a function of the ecology, physiology, and genetic diversity of a species, which are in turn influenced by external factors like resource management and habitat changes. Vulnerability can be mitigated by the adaptive capacity of the species, which is also a function of the ecology, physiology, and genetic diversity.

The primary components of the modified vulnerability assessment framework are climate stress, landscape exposure, and adaptive constraints. Climate stress combines an estimate of exposure from the projected regional climate changes and an estimate of the sensitivity of biodiversity in an area from a coping range derived from historical climate variability. Landscape exposure indicates how exposed biodiversity may be in a particular location based on a series of exposure-buffering features including metrics derived from topographic, hydrologic, and geographic datasets. Adaptive constraints measures how fragmentation and land use can reduce the adaptive capacity of the species. Climate stress, landscape exposure, and adaptive constraints are combined to estimate biodiversity's vulnerability to climate change based on landscape-scale indicators.

Assessing the vulnerability of individual species may be an important step to develop and prioritize adaptation strategies, but these assessments are costly, time consuming, and rely on data that in many cases do not exist. The potential impact of climate change on biodiversity is well established in the scientific studies, but there is much less research on what managers can do to reduce the impacts and help biodiversity adapt to climate change. Researchers are highlighting the importance of identifying and protecting landscape- scale features such as topographic and climatic heterogeneity, elevation gradients, solar insolation, soil type adaptation to climate change

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THE LONG-TERM CHANGES OF INTENSITY AND FREQUENCY OF HEAT WAVES IN THE CONTEXT OF CLIMATE CHANGE (CASE STUDY IS THE ARARAT VALLEY)

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Abstract

The long-term daily air temperature data have been studied, investigated, analyzed and evaluated for surveying the intensity of heat waves and their long-term frequency range observed in the context of climate change. The main studies have been done for the Ararat valley, as the intensity of heat waves is typically defined here. Daily maximum temperatures of 5 meteorological stations (Ararat, Artashat, Merdzavan, Armavir and Arabkir) are observed. We have analyzed and calculated the absolute maximum air temperature, the number of days with absolute maximum temperatures above 38°C and the number of observed heat waves (5 days and more observed absolute maximum temperatures above 38°C) for 1960-2016 period. The synaptic conditions of the formation of heat waves, their frequency and intensity, and duration have been analyzed. A number of features and patterns have been revealed. In the region and particularly in the Ararat Valley, the intensity of the thermal waves and the frequency increase has been observed especially after 2000.

Key words: Heat wave, frequency and intensity, absolute maximum temperature, climate change

Introduction

In different countries of the Earth heat wave is analyzed and defined as a concept differently. Heat waves are usually the result of air accumulations with hot and extremely hot weather conditions which can be considered disastrous weather phenomena [1].

Heat waves are common phenomena during the summer, when the region has a long, intense, direct solar radiation. In case of long-term isolation, the temperature continues to increase, and heat intensities are formed in the absence of weather activity. Heat waves are defined differently in a variety of circumstances, usually in different regions. The observed high temperature should last at least three days to be called as a heat wave, but usually it lasts from a few days to a couple of weeks [2,3].

The physical geographical and climatic conditions of the Ararat Valley contribute to the more frequent and intensive cases of heat waves. The most intensive and frequent heat waves in the territory of Armenia are observed in the Ararat Valley. Moreover, the Ararat Valley, being an important agricultural region for the republic, is on the center of the specialists' attention.

Materials and methods

As a methodological basis for the work, the general principles and approaches are integral, systemic, ecological, geographical and territorial studies.

The general scientific, characteristic, comparative, statistical, coherent, systematic analysis, cartographic methods and methodological implements have been used in the work.

The following data have been applied in the work: Data taken from Hydro-meteorological Service of Armenia, from Air Temperature Monitoring Data center, reports from relevant regional authorities, scientific data, as well as data available on the Internet. Our issue was to study, analyze and evaluate the multiannual intensity and frequency of heat waves by the example of the Ararat Valley. The main source of the study was the observations of the average and absolute maximum air temperature series for 5 meteorological stations (the following stations in the Ararat Valley: Ararat, Artashat, Armavir, Yerevan-Arabkir and Merdzavan) for 1960-2016 period. To implement the main study, we have selected and analyzed observed absolute maximum temperatures above 38°C. As a result of these data analysis, different graphs and tables have been obtained. This choice is largely determined by the fact that the maximum temperatures above 38°C results in a certain pattern of heat waves monitoring in the region.

Results and discussions

Climate change is a change in the statistical distribution of weather conditions when it happens during an extended time scale (it can be from decades to millions of years). Climate change may refer to changes in the average weather conditions or long-term fluctuations in the average weather conditions, as well as changes in weather extreme conditions. By analyzing and estimating the absolute maximum air temperature above 38°C in meteorological stations, we have had high temperature increase, which is mainly observed after the 1990s.

The appearance of heat waves in the Republic of Armenia and particularly in the Ararat Valley is mainly conditioned by southeastern air masses, seen from the Arabian deserts by the influx of hot air [4].

By examining the absolute maximum temperatures on a daily basis, we can clarify and present the frequency and intensity of the heat waves. Based on different provisions and geographical conditions of the study area, we have adopted the absolute maximum temperature of more than 38°C which should last for at least 3 days and more can be considered a heat wave.

Based on the data, the number of extremely hot days was changed between 1960 and 1990, when the number of days and above do not exceed 8 days. Moreover, there has been a growing tendency in the number of days with maximum daily temperatures 38°C during 1990-2016.

For analyzing the dynamics of heat waves, we have worked out the number of days with cases of heat waves by years, and the reason for this is the average number of observed cases of all stations, which is presented in Fig. 1.

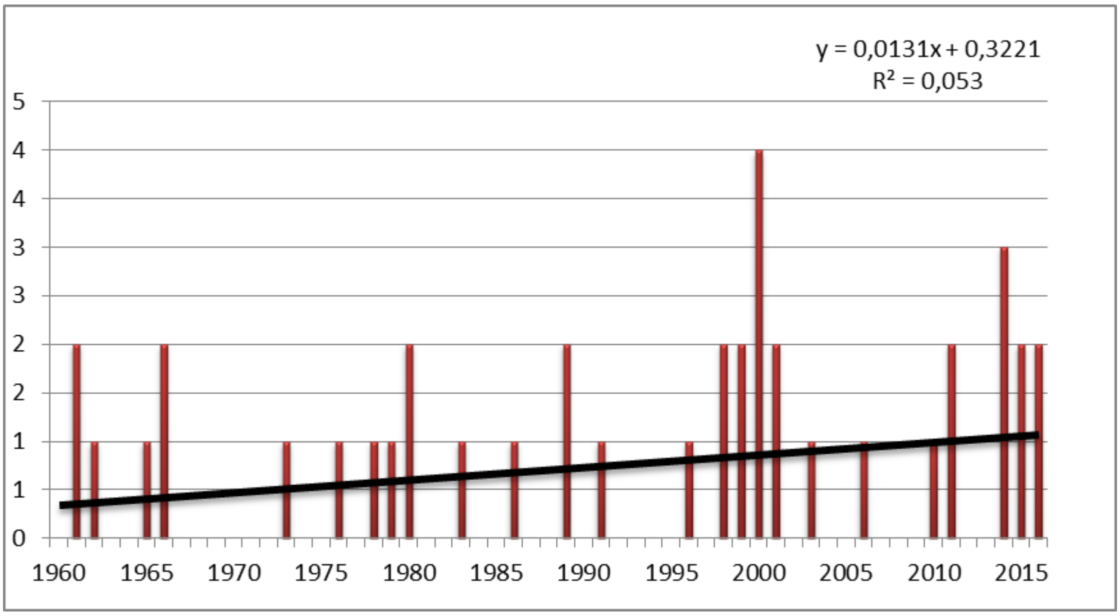

Fig. 1. Number of observed heat waves in Ararat Valley by years (1960-2016)

Obviously, the number of heat wave cases observed in Ararat Valley has been increased in recent years, and very few studies have been done about them.

According to the analyzes, the number of heat waves in the 1948-2008 period, particularly in 2006 from August 7-17 to August 28-31, as well as on September 1-3, the air temperature in the Ararat Valley 5 day was around +40 - +41°C.

A similar phenomenon was observed in 2015, particularly in July and August. The air temperature in the Ararat Valley from July 25 to August 6 fluctuated from +38 to + 41°C, and from August 12 to 21, the air temperature fluctuated between +37 ... + 42 ° C.

The maximum number of heat wave days with 38˚C and above absolute maximum temperatures were observed in Artashat meteorological station about 192 days, and minimum number of days in Armavir meteorological station around 66 days.

Analyzing also the mulitannual frequency curve of the absolute maximum temperature of the air, it was possible to compile the graph below (Figure 2).

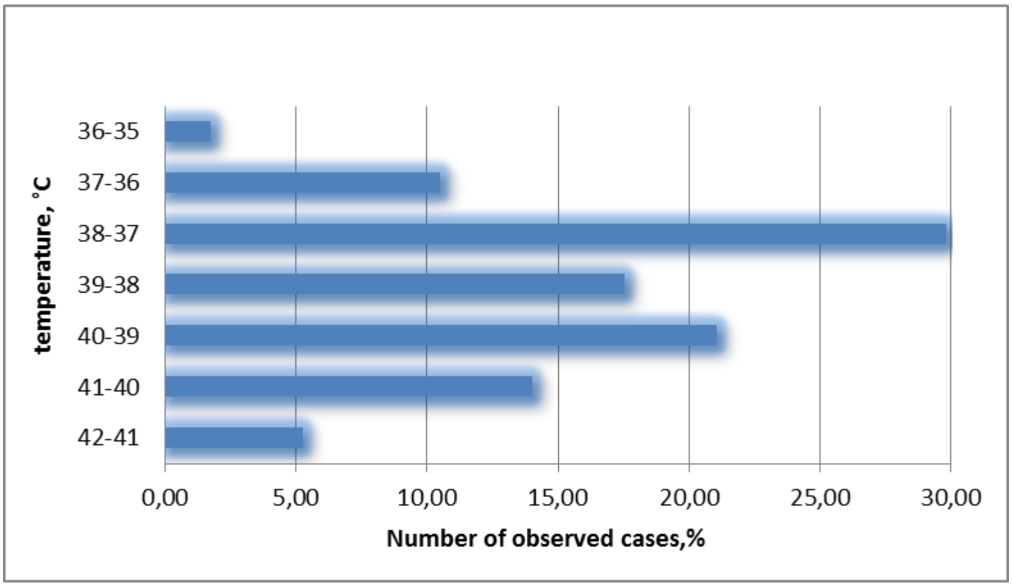

Fig. 2. Frequency curve of absolute maximum temperatures in Ararat Valley

The graph shows the absolute maximum temperature for 56 years and it is obvious how frequently temperatures above 35°C are observed over the period.

The highest percentages expressed are +37 and + 38°C, about 30% frequencies, with a temperature of +40 and +41°C about + 22% 6% frequency are +41 and + 42°C and with a minimum +35 and + 36°C. As we have mentioned above the lowest degree for our study is 38°C and in this case the hightes frequency possipility to be occured is from +37 to 38°C about 30%. This means that during summer time alost one mouth is possible to have heat waves in Ararat valley.

Analyzing the years of heat waves in the territory of the Republic of Armenia, particularly in the Ararat Valley, there are cycles of activations and relaxtions in this process, presented in Fig. 3.

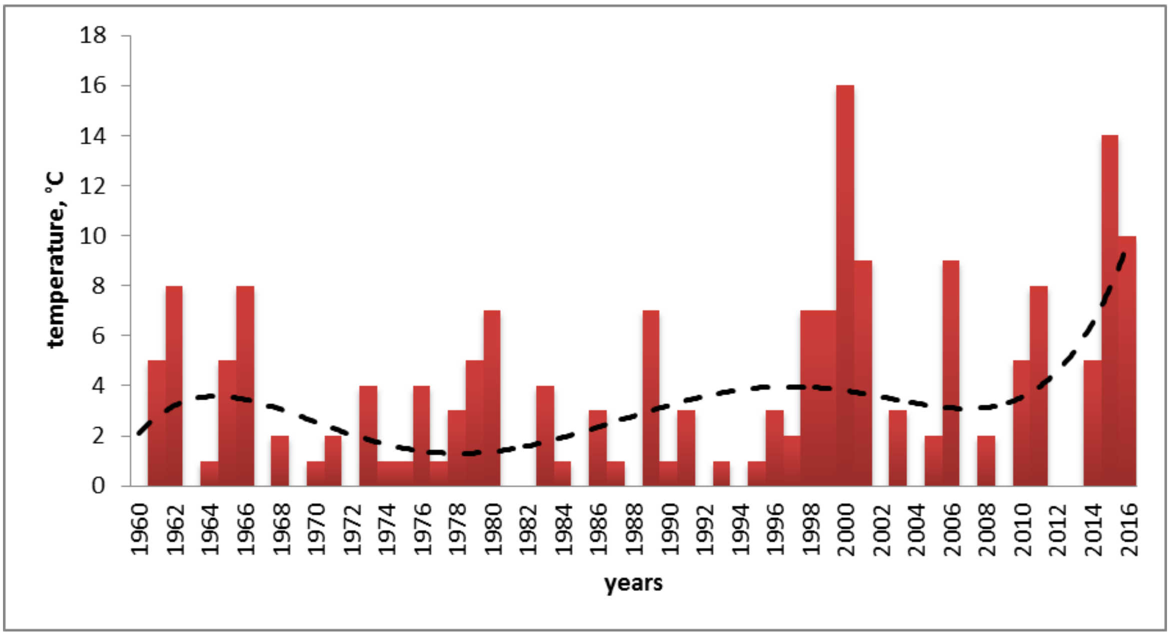

Fig. 3. The number of days observed heat waves in 1960-2016

In the study it is selected a 5-year polynomial trend, which reveals the period of frequency of heat wave days number, the cycles of their activations and relaxations during 1960-2016. It is visible from Fig. 3 that the cycles are manily for 9 and 11 years, which is neturally happened phenomena.

The observed frequency of heat waves is caused by number of climatic condition changes. In case of predicted increasing temperature and deceasing precipitation, it is necessary to expect climatic drainage, drought and desertification accelerations. Moreover, the boundaries of landscape zones will move in mountainous areas up to the height of 200-300 m [5].

Having dry climate conditions, particularly in the Ararat Valley, high dryness ratio is observed, which causes drought conditions [6].

The drought assessment was carried out in the Ararat Valley according to the Hydrothermal Coefficient of Selyanino. It was used Ararat meteorological station data from the second decade of April till the second decade of October for 1960-2010 periods [1]. The total number of severe strong and strong droughts was recorded in the Ararat Valley during the study period. Drought cases are ranging from 4 to 12 cases in Ararat. Most cases were reported in Ararat in 1961 and in 1987 - 12 cases, at least in 1966 - 4 cases.

The most dangerous is the period when drought conditions occur continually a few decades. Thus, in 1961, in Ararat station, in 11 consecutive decades, strong and very strong drought conditions were observed, and in 1978, 1987, 1994, 2008 and 2010 about 8 consecutive decades. Assessment of drought conditions has been planned for all regions of Armenia, which is included in the Hydrometeorological Service's 2012-2015 work plan.

Conclusions

Summarizing the work the following conclusions can be done:

- In 1960-2016 the maximum number of cases of heat wave was observed in 2015, particularly in July-August. From July 25 to August 6, the air temperature in the Ararat Valley fluctuated from +38 to + 41 ° C and from August 12 to 21, the air temperature fluctuated from +37 ... + 41.8 ° C.
- The number of days with 38˚C and above temperature in the studied period has a regular repetition, but its number has been increasing after the 1990s, although there were also years when 38˚C and above were not observed. The highest temperature was recorded 42.2˚C in the Ararat station in 2000, where the highest number of the heat wave cases was recorded.
- As a result of the research the maximum 192 days, with absolute maximum temperature 38°C and above, have been observed in Artashat station and the minimum was in Armavir station for 66 days during 1960-2016 period.
- The observed frequency of heat waves is caused by number of climatic condition changes. In case of predicted increasing temperature and deceasing precipitation, it is expected drying climatic conditions, drought and desertification accelerations.

In sum, it can be said that the current and expected climatic changes are rather complicated to explore and predict with high levels accuracy. The results and conclusions of the phenomena that are definitely on a global scale should not be distributed to individual areas of the globe to evaluate local changes.

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DYNAMICS OF LANDSLIDE AND GRAVITATIONAL EVENTS IN GEORGIA AND RISK FACTORS OF THEIR DEVELOPMENT (CASE STUDY OF IMERETI)

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Abstract

Georgia is one of the most distinguished countries among mountainous regions in terms of the scale of natural disaster development, vulnerability, natural disaster frequency and their impact on the population and economy. Nowadays in Georgia approximately 53 thousand landslide bodies, 3000 cell transforming erosional rivers, more than 5000 avalanche prone territories and 1500 abrasion zones are registered. In total 70% of the territory of the country and approximately 3000 settlements are under the danger of natural disasters.

The most devastating and dangerous natural disasters in Georgia are landslide-gravitational processes. These processes can be met in every climatic-geomorphological zone and can cause large scale damage.

In recent decades the activation of landslide-gravitational processes is caused by different factors, such as: high intensity earthquakes in Caucasian region; increased human pressure on geoecological environment and the disruption of its balance; and of course, increased number of meteorological events (rainfall, humidity) because of global climate change.

Key words: Tecto-seismo-gravitational, technogenic, climatogenic (consistent), landslide.

Introduction

1,5 ml hectares of agricultural land in Georgia have been damaged in varying degree and exceeds useful funds, which is alarming. Georgia is one of the eminent regions with varying degrees of development of multi-criterion natural disasters (landslide, heavy rains, flooding, water-erosion, avalanche) vulnerability, repetitive frequency and negative results inflicted on population and economy. At present, there are up to 53 thousand landslide and gravitational spaces with the areas in risk of their occurrence, up to 3000 water drains, which may be transformed into mudflows, more than 5000 areas of avalanche, more than 1500 areas of eroding river and about 2000 km long seashore. 70% of the territory and up to 3000 populated areas are in these risk zones. We do not say anything about risks of earthquakes with 7-9 magnitude, under which is almost whole Georgia. Earthquakes directly impact and stimulate landslide-gravitational events. [1]

Materials and Methods

The article is based on the research (materials obtained through fieldworks and analysis of the existing information sources) conducted by the staff of Department of Geology of National Environmental Agency and Department of Geography, Geomorphology and Cartography Department of the Faculty of Exact and Natural Sciences of Iv. Javakhishvili Tbilisi State University [1].

Results and discussions

In Georgia, most impressing is landslide-gravitational events. We can observe these events in every climatic geomorphological zone and it has outrageous results. From many negative consequences of landslide-gravitational events, there are some important cases, for example 25-30% of populated areas, roads, oil and gas pipelines and shores of large reservoirs. Currently the Zhinvali reservoir is under the landslide process risk and this reservoir is a main source of water supply. 2715 events were reported in the area of listed engineering objects. It is important, that 70% of mudflows, which were formed in the country's mountainous landscapes, are directly related to the landslide-gravitational processes. 80% of total harm of population, infrastructure and environment, 70% of economic harm is based on landslide-gravitational processes. It should be noted that more than 80% of the 60000 families, who have been moved to various places as eco-migrants in the last 45-50 years, have been related to the same events in Georgia.

In 1987-1989, landslide disasters were almost in whole of Georgia. The total number of active landslides was more than 30000; 7735 landslide bodies were recorded in the populated area, up to 20000 houses and agricultural objects were collapsed and damaged, up to 50 people and part of the village of Tsablana were buried in Achara in 20 million cubic meters of landslide rocks (region of Khulo). In 1991-1992, high energetic earthquakes of Racha-Imereti and Phasanauri-Barisakho provoked up to 2000 landslide-gravitational events, which negatively affected up to 1500 populated areas, died up to 100 citizens and up to 332 000 ha lands became useless. Khakhieti Village (Sachkhere) was buried under the 70mln m^3 landslide rocks and the village of Chordi with 70 households was fully destroyed by the 150 mln.m^3 landslide body, part of Zhashkhviri and Bajikhevi (region of Oni) was also destroyed, also Tskhinvali region's villages Beloti and Satskhenisi were fully eliminated [1].

Recently, development and reactivation of landslide events in Georgia have led to the ongoing geodynamic processes in the sensitive geological non-static process and complication of geo-ecological situations:

1. Activation of high intensity limits in the Caucasus (Tecto-seismo-gravitational)
2. Extremely high pressure on a geologic environment and sharp rupture of its balance, which caused extremely high pressure of human.
3. And the most important, negative meteorological events to enhance landslide processes on the common background of global climate change (atmospheric precipitations, humidity) [2, 4].

Tecto-seismo-gravitational landslides (Fig. 1.) are localized near tectonic trenches and faults; they have deep allocation and a big volume.

Fig.1. Tecto-seismo gravitational landslide

Tecto-seismo-gravitational landslides are related to earthquakes and are repetitive. As a classical example of tecto-seismo-gravitational landslides in Imereti, we can name the following: Vakhani, Boriti-Sakasria, Amashuketi-Akhalsopeli, Mukhuri-Khreiti, Korbouli-Gorisi, Perevi and Goni massif. [1].

Landslides, whose origin is caused by the regimen of atmospheric precipitations, sharp water cutting quality and the "humidityeffect'' power supply caused by it, on what depends the constant changes of wetting rocks and decrease of bone resistance to critical levels, are called **climatogenic** (**consistent**) landslides (Fig. 2).

Landslides of this kind massively develop in Georgia, and they are more than 70% of the total number. They are different in every climatic–geomorphological zone, which has more than 5-8^0 inclined surface, and the slopes are constructed by acceptable atmospheric precipitations and sensitive rocks.

Regional geo-monitoring and regime-stationary statistical analysis show that dynamic regime of climatogenic landslide processes is directly related to the magnitude of atmospheric precipitation in the annual interval and this is from the statistics of many years in the land-geologic area. Their activation period and positive balance of atmospheric precipitations are the same, and the decreasing process or temporary stabilization is the same period as the deficit of sediments.

Fig.2. Climateogenic landslide

Also decreasing process or temporary stabilization is directly related to syncretization of elements of the geological environment. Specifically, when the number of precipitations is in the boundaries of the multiannual norm (this means that it is same as the conditions of climate regime), the dynamic regime of landslide processes, in case of excluding other additional risk factors, is in process of background level.

When the positive balance of atmospheric precipitations that have come during the year is within the multi-annual norm (100-200 mm), the landslide process mode becomes more and more active. When atmospheric precipitations that have come during the year is exceed the multi-annual norm (200-400 mm), it stresses the development of the process; almost every temporary stable landslide becomes active and new landslides are being created in this geological area, whose deformation horizons are characterized by highly sensitive and synthesized symptoms [2, 4].

Considering the risk of increasing landslide-gravitational events, which is a consequence of changing in global climate and the hazard of strong earthquakes, it is necessary to have real information about the scale and the potential danger from these types of processes. One of the important methods to protect the population and avoid discomfort is well-organized and permanently implemented geomonitoring studies of different levels. These studies include observation, control, evaluation, prediction and management of events.

Early information received according to the results will be sent to the population and relevant organizations with recommendations. On the other hand, studies have confirmed that the exposing and studying of landslide-gravitational events help seismologists to learn more about outside urban areas and unknown paleoearthquakes. Thus, geomorphological studies of this type can be seen as an important method for determining the existence of historical earthquakes.

The technogenic landslides (Fig.3.) are entirely conditioned by human agriculture and engineering activities, and wrong intervention of human in the geological environment has also an important influence in their formation and activation. Region Imereti is very good example of it. In Imereti, Intensive use of Imereti's agricultural lands and urban territories created favorable conditions for accelerated anthropogenic erosion and development of landslide processes. A good example of this is Kharagauli and Sachkhere-Chiatura, which resulted in dismissing hundreds of hectares of lands from the farming fund [5, 6].

The **technogenic** landslide-gravitational processes are presented in a wide range at individual housing construction sites and along the roads. Studies have shown that 35-40% of landslides originated within urban areas and 70-80% of landslides developed along motor roads are caused by human wrong activities.

The Zestaponi-Rikoti highway is noticeable in this regard, where the rocks of slopes created during road reconstruction in the 70s of the 20th century are still present in the process of renewing gravitational exposure and it will continue until the establishment of a homeostatic state. Many landslides are caused by the construction of roads near the rivers of Kvirila, Rioni, Tskhenistskali, Khanistskali and Kutaisi-Tkibuli road section.

From the point of view of complication to the natural environmental transformation, development of landslide processes and the crisis of geoecological conditions, there is no analogy in Georgia to the **technogenic** pressure caused by the mining of Chiatura manganese ore. In the past 100 years of exploitation, the area of anthropogenic terrain exceeded 150 km^2 here and the total length of miners exceeded 200 km [1, 10].

Result of all these was creation of mining geological processes (burning the roofs, belittle, retard, moving the rocks) and development of landslide processes. This kind of geodynamic processes completely destroyed several villages and the scale of deformed and destructed individual houses exceeded 2500 in the mining area: villages Darkveti, TK, Perevisa, Shukruti, Mghvimevi, etc. [3].

Fig.3. Technogenic landslide

Conclusion

We consider that for the criterion of estimation of natural disaster risk it is necessary to take into consideration the result of the final process of disaster, as well as the risk of hazardous emergency situations, which is often expressed with frequency and intensity. The estimation of the risk of natural disasters should provide both direct and indirect impacts. For example, we distinguished four categories according to the risk of landslides in the Imereti region:

1. Territory with a high level of damage caused by landslides and high risk of danger for residents and important engineering objects;
2. Territory with damaged agricultural lands caused by landslides and low risk of populated areas.
3. Territory with law damage caused by landslide processes, low risk for population and engineering objects.
4. Territory practically undamaged by landslide processes and very low risk of potential damage.

To sum up everything, we can observe that ensuring the safety of the population and safe spatial distribution of industrial-engineering objects can be ensured only with conduction of holistic, complex measures against different devastating processes and not against only one process (in this case – landslides) (1,6).

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NUMBER OF BLIZZARD DAYS ON THE TERRITORY OF GEORGIA

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Abstract

Most of the territory of Georgia occupies mountain landscape and the development of mountain regions has high value for country. For the development of mountain health resorts it is important to liquidate in proper time the negative consequences of different dangerous weather phenomena, including blizzard. Also, it is important to introduce effective measures to eliminate the consequences of the blizzard for the smooth operation of Georgia as a regional transport hub. In the present study the number of days with a blizzardhas been investigated. There are presented geoinformation maps of average and maximum blizzard days for Georgia. The number of blizzard days has been studied according to the materials of observations made at 86 meteorological stations of Georgia withinthe period of 1966 - 2017. Obtained results will be used to carry out preliminary measures to minimize damage caused by blizzard.

Key words: Blizzard, climate, dangerous meteorological phenomena, geoinformation map.

Introduction

Dangerous meteorological phenomena are extreme weather events creating emergency situations. Such phenomena include droughts, frosts, hurricane winds, hail, blizzards, etc. They bring significant material damage and often cause human casualties [1]. Blizzards belong to such dangerous meteorological phenomena.

Blizzards are always associated with more or less strong loss of visibility. Impairing visibility, they create great difficulties in the functioning of transport. As a result of the blizzard the electric power lines can be disrupted. The blzzard disturbs the balance of the snow cover and generates snow cornices, snowdrifts and other unstable forms of snow. Due to the limitation of horizontal vision, the blizzard createsgreat difficulties for aviation. Blizzard causes significant damage to agriculture as well.

Blizzards extend through the entire territory of Georgia, especially in the regions with steady snow cover; they are predominantly observed on the passes of the Caucasus, Adjara-Imereti, Surami, Trialeti and on the mountains of Samtskhe-Javakheti [2]. In the mountain regions of Georgia blizzards occur from November through April. Only in the highest parts they are observed from October through May and are very rare in September [3]. Climatological study of blizzard, in particular, research of the number of days of blizzard in the last 50 years, has a purpose to provide information on the territorial distribution of blizzard in Georgia. In the present article, based on existing data covering the period from 1966 to 2017, the largest and average numbers of blizzard days have been studied.

Data from 86 meteorological stations on the territory of Georgia (accordance to periods 1966-1992 and 1966-2017) were used as source materials for mapping.

Materials and methods

For the work the followingmaterials were used: Archive data of the Institute of hydrometeorology at the Georgian Technical University,climatic reference books and National Environmental Agency observational data.

In the study was used the methodology of mathematical statistics and probability theory. Also, the methodological basis of the study was processed at the department climatology and agro meteorology of the Institute of Hydrometeorology of Georgian Technical University.

Results and discussions

One of the important indicators of blizzard processes is the number of blizzard days. The distribution of the number of blizzard days in the territory of Georgia depends to a large extent on the physical-geographical conditions.

The nature of the blizzard is determined by the following conditions: a quantity of falling out solid precipitation, speed and the direction of the winds, the configuration of relief and protection the related connection points. The intensity of blizzard strongly depends on the speed of snow-wind flow, power and nature by snowcover, size of snow particles, also, temperature and humidity of air [4].

In the territory of Georgia blizzards are related tothe invasions of cold air masses both from west and east. Blizzards, related to the western processes, cover almost entire territory of Georgia. In western Georgia they are accompanied with snowfalls; in the remaining regions they can bear the nature of ground blizzard. During the eastern processes blizzards cover entire eastern Georgia and significant part of the upland of Southern Georgia, sometimes being extended into the mountain alpine regions of Western Georgia [5].

Tab. 1 presents the average and maximum number of blizzard days during the year for the territory of Georgia. The table shows the data of 86 meteorological stations for the last 50 years, where more than one case of blizzard is recorded during a year. Meteorological stations and checkpoints listed in the table include almost the entire territory of Georgia, which allow us to better analyze the number of blizzard days during the year. The table also shows the heights of meteorological stationsabove sea level. By this it was possible to determine dependence between the number of blizzard days and the height of the place, which is a subject of our future research.

Table 1.

Average and maximum annual number of blizzard days in Georgia, 1966-2017

Meteorological station/post	Average annual number of days	Maximum annual number of days	Height above sea level, m
Mestia*	2.1	16	1500
Cholashi*	1	4	1900
Becho*	1.3	6	1660
Kuruldashi*	2.7	21	1940
Murshkeli*	1.7	5	2040
Zeskho*	12.3	27	1800
Dizi*	1.5	16	1080
Gebi*	1.3	6	1350
Lebarde*	1.6	18	1600
Sno*	3	10	1760
Tsinkhadu*	10.7	20	1910
Pass Mamisoni*	146	235	2854
Kazbegi, h/m*	129	346	3665
Kazbegi*	17.8	86	1750
Gudauri*	10.5	41	2196
Kveda-tlugi*	3.6	16	1080
Tsipa*	1.7	11	673
Pass Djvari*	39	70	2380
Shqmeri*	3.8	24	1720
Khiso*	2.6	15	1750
Zemo-akhalsopeli*	3.5	30	1560
Chiatura*	1.7	10	500
Mlashe*	1.5	11	940
Tkibuli*	1.5	16	590
Beshtasheni*	2	11	1540
Sagaredjo*	1	10	740
Lelovani*	2	9	1220
Korbouli*	13.7	33	790
Kharagauli*	1.3	8	275
Saqara*	1	8	300
Tianeti**	2.5	16	1100

Ksovrisi*	1.4	9	640
Dimi*	2.4	12	200
Nabeglavi*	1.6	11	470
Mta-sabueti	29.5	105	1248
Reserve Lagodekhi*	1.5	6	450
Aragva*	17.3	74	1669
Dzegvi*	1.2	9	560
Khashuri**	3.8	11	700
Gori*	1	8	588
Tsagveri*	12.7	10	1130
Libani*	1.5	7	1370
Bakuriani, Andesite*	12.7	36	1800
Adigeni*	2	7	1240
Tabatskuri*	19.8	33	2000
Gombori**	1.7	14	1550
Bakhmaro**	27.5	135	2050
Pass Zekari*	17.8	100	2182
Kushchi*	4.1	15	1540
Sakdrioni*	3.5	10	1540
Khertvisi*	1.7	17	1250
Poka**	31.3	63	2080
Bakuniani**	8.4	35	1700
Araqali*	16	50	1890
Orodjolari*	12.5	31	1880
Sagamo*	21.2	36	1996
Manglisi*	7.2	36	1900
Ckhratskaro*	90	163	2462
Kodjori**	2.7	16	1400
Akhaltsikhe*	1.5	15	1000
Tsalka**	3.8	21	1460
Kartsakhi*	22.8	58	1860
Pavliani**	2.5	28	1350
Udabno*	3.4	28	750
Kekhvi*	1.5	5	956
Paravani*	43	117	2073
Dedoplistskaro**	1.5	6	800
Civi-tura*	8.3	68	1990
Dmanisi*	6.7	26	1171
Ninotsminda*	11	36	1940
Ermani*	28.9	64	2220
Epremovka*	24.9	90	2110
Tskinvali*	4	21	870
Akhalgori*	1	6	800
Tsiskara*	3.6	34	1200
Ridge Gagra*	29	73	2432
Gvandra*	1.7	10	800
Khulo*	5.9	26	923
Pass Goderdzi**	79	162	2025
Charnali*	1.7	14	120

Rikoti*	1.2	13	996
Akhaldaba*	1	9	760
Sioni*	1.6	19	1000
Chokhatauri*	1.5	18	150
Anaklia*	1	7	30
Batumi*	1.3	16	5

*Data for 1966-1992 years; ** Data for 1976-1991 years.

As shown in the Tab.1, the average number of blizzard days varies from 1(a few points) to 146 (Mamisoni Pass) days per year. As for maximum number of blizzard days, data varies from 4 (Cholashi) to 346 (Mountainous Kazbegi) days.
Based on existing data geoinformation maps of the average annual and maximum annual of blizzard days (Fig. 1, 2) have been created.

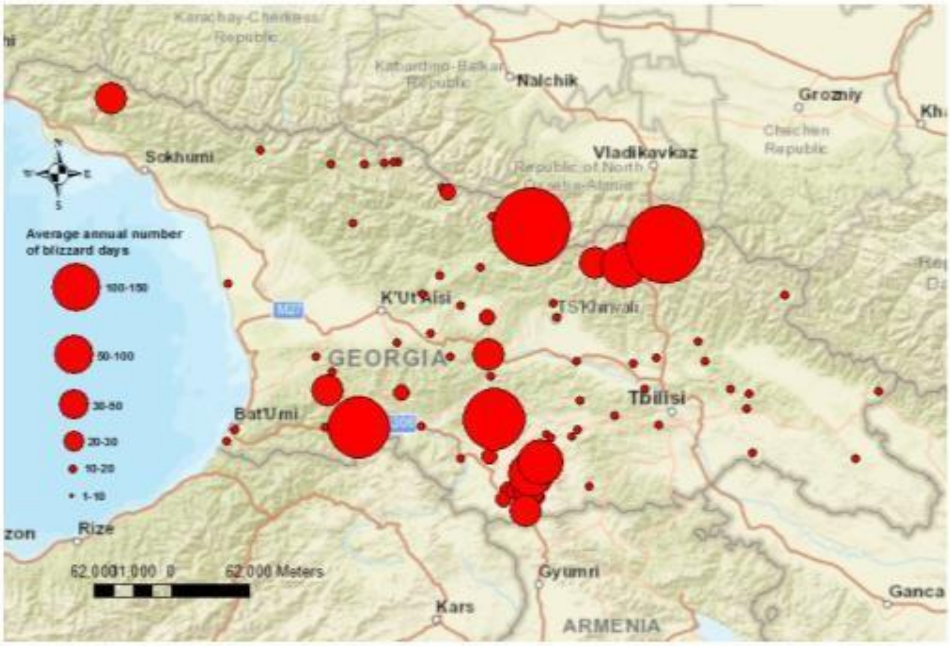

Fig.1 . Average annual number of blizzard days in Georgia

Fig.1 shows the distribution of average annual number of blizzard days in the territory of Georgia. As it turns out from the map, average annual data is not high for the most part of the territory of Georgia and varies from 1 to 10 days a year; though, also there is a large part the territory of Georgia, where average blizzard days vary between10 - 50 days per year. And the higher data of the average number of blizzard days are fixed at several points.

High data of the average annual number of blizzard days are observed mainly on the southern slopes of the Caucasus Mountains, also in the vicinity of the Likhi and Trialeti ranges and the Javakheti plateau, in the latter the average number of blizzard days is particularly high. It should be noted that the average annual number of blizzard days are quite low on the southern slopes of the Caucasus for the main part of western Georgia than on the southern slopes of the Caucasus for eastern Georgia, and mostly varies within 1 –10 days.

Fig.2 shows the distribution of maximum annual number of blizzard days in the territory of Georgia. As the map shows, maximum annual data that varies from 1 to 10 days and also the data that varies from 10 to 20 are observed in equal amounts and their total number covers most part of the territory of Georgia. Also, the data of maximum numbers of blizzard days covers the large part of the territory that ranges within 20-50 days. A higher figure is observed in a relatively small area. It is noteworthy that the southern slopes of the Caucasus Mountains are the points where the maximum number of blizzard days is observed more than 200 days a year. Such points are the Mammisoni Pass, where the maximum number of blizzard days are 235 days a year and the mountainous Kazbegi, where the maximum number of blizzard days are 346 days a year according to the data of the last 50 years.

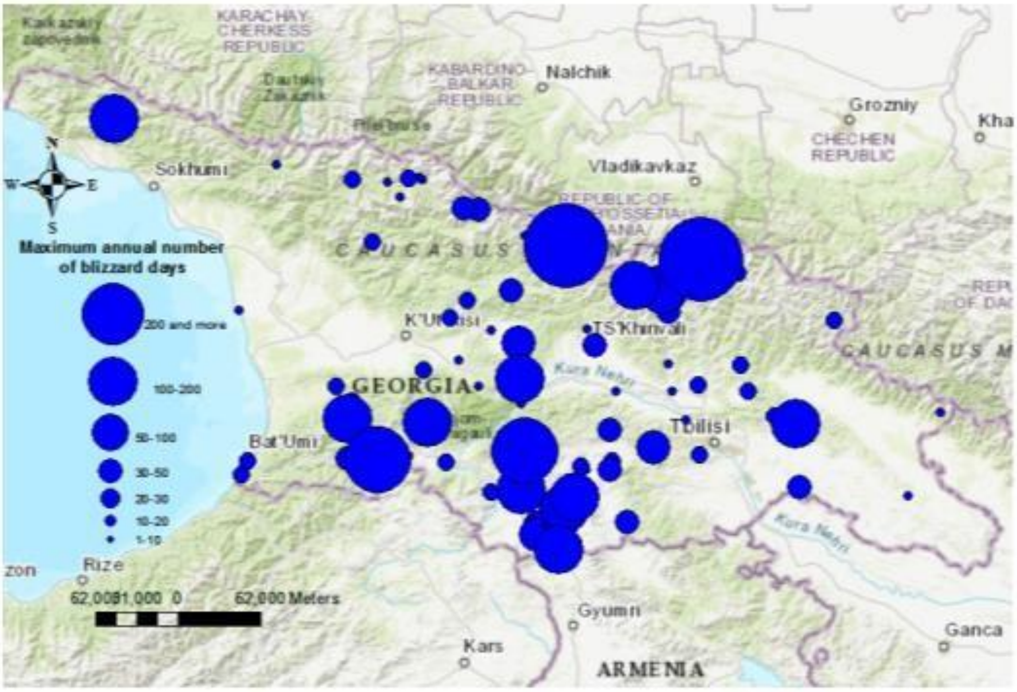

Fig.2. Maximum annual number of blizzard days in Georgia

As it is known, Georgia is aimed at promoting tourism and winter sports events forthe development of mountain resorts. In this regard it is important to study the number of blizzard days according to the municipal regions of Georgia in order to better plan the reduction of damages caused by blizzards [6]. Fig.3 shows the distribution of the maximum annual number of the blizzard days in the last 50 years according to the municipal regions of Georgia.

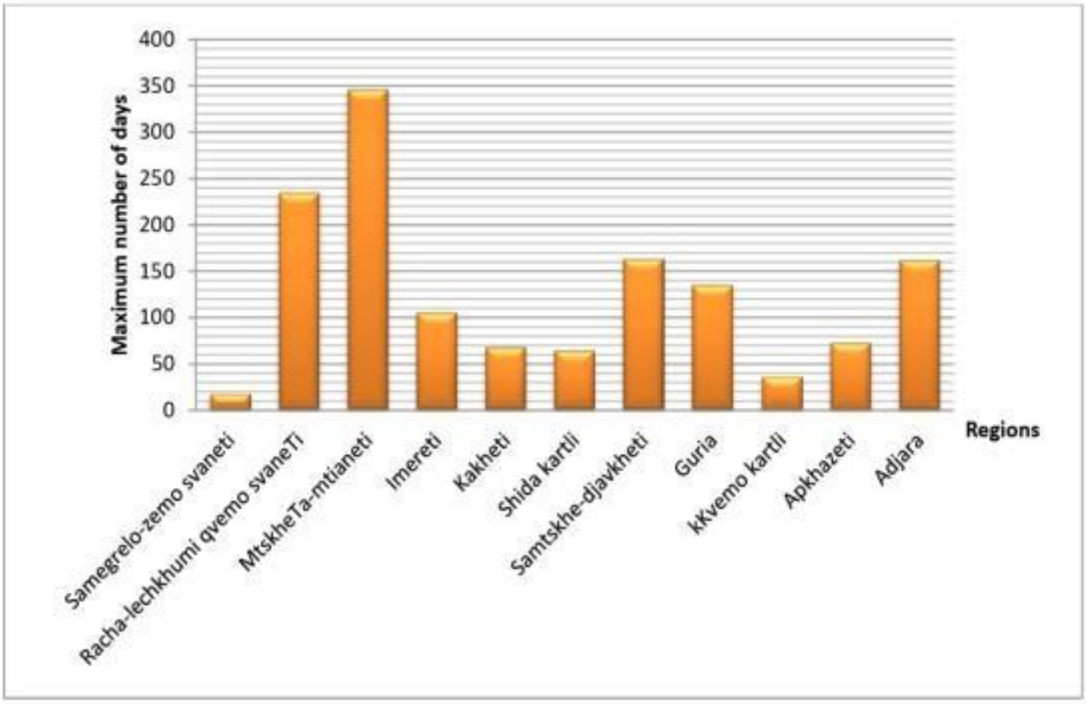

Fig.3. Maximum annual number of blizzard days by regions in Georgia.

According to the Fig. 3 the highest maximum number of blizzard days per year is observed in the regions of Mtskheta-Mtianeti and Racha-Lechkhumi – Kvemo Svaneti, followed by Samtskhe-Javakheti, Achara and Guria, where the maximum number of blizzard days is also high.

Conclusions

According to the data of the last 50 years on the territory of Georgia, and according to the distribution of the number of blizzard days, it can be concluded that the average and maximum number of blizzard days in most areas of Georgia are low and are characterized by less blizzards.

However, in the highland regions, these data are quite high that can cause great damage and threaten the sustainable development to these regions.

Acknowledgements

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SESSION 5. LANDSCAPE PLANNING, ECOSYSTEM SERVICES, AGROLANDSCAPES

CULTURAL HERITAGE CAN SUPPORT SUSTAINABLE LANDSCAPE DEVELOPMENT – A STUDY FROM THE TREBON BASIN, CZECH REPUBLIC

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Abstract

The European Landscape Convention, which is widely adopted by governments, refers to the role of landscape – defined as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" – and sustainable development in regards to the sustainable use, protection, management, and/or planning of landscapes [1]. In this paper, we explore if and how the cultural heritage in the Trebon Basin, i.e. the artificial fishponds and lakes that were mainly built in the 15th – 16th century, is contributing toward sustainable landscape development. Tracing the historical development of the area we argue that this phenomenally engineered large-scale system of ponds is uniquely adapted to the local landscape conditions and may have survived into the 21st century due to its economic production value from aquaculture but also due to the recreational opportunities, biodiversity and aesthetic values this landscape provides to the present day. Current threats to the landscape and potential remedies for sustainable landscape development are discussed.

Key words: Vernacular landscape, cultural landscape, rural livelihoods, multifunctional landscape, cultural sustainability, rural sustainability

Introduction

The European Landscape Convention was initiated by the Congress of Regional and Local Authorities of the Council of Europe with the aim to promote European landscape protection, management and planning, raise awareness of the value of a living landscape, and to organise European co-operation [1]. The Czech Republic ratified the Convention, which came into force in 2004, thereby committing itself to recognise the value of landscape in terms of the environment which surrounds all human beings and which shall be preserved and protected. Also, it committed to introduce and execute landscape policies aimed at landscape protection, management and planning, introduce steps to enable the public to be involved in decisions related to landscape protection, and consider landscape in urban and land use planning as well as cultural, agricultural and social polices [2].

Using the Trebon Basin, Czech Republic as a case study, the aim of this research was to explore if and how the cultural heritage features, i.e. the artificial fishponds, lakes and channels, contribute toward sustainable landscape development in the Trebon Basin. Tracing the historical development of the Trebon Basin landscape – understood here as a linked place-based social-ecological dynamic system that evolves over time – we also identify current threats and challenges confronting the basin. Further, we discuss potential remedies for sustainable landscape development.

1.1 Conceptual framing of sustainable landscape development

In this section, we derive the logic for our conceptual framing of 'sustainable landscape development'. First, we define the concept of landscape used in this paper and stress the importance of collective human practices associated with various landscape functions to define sustainable landscape development.

While there is no single definition or concept of landscape [3], at its most basic level, landscape represents the relationship between people and place (Fig. 1). Landscape provides the setting for people's day-to-day activities and results from the way that different components of the environment – both natural and cultural – interact and are perceived and imagined by people [4]. The outcome of this synergy creates dynamic and evolving landscapes, which are consequently multifunctional and cultural, and best understood contextually and historically [5, 6, 7]. Capitalising on the multiplicity of approaches to landscape, Tress and Tress [8] established a transdisciplinary systems approach to landscape research, almost two decades ago, to develop solutions to environmental, social, cultural, aesthetic and economic problems. Linking transdisciplinary landscape research and sustainability science further advanced both fields through the development of new integrative frameworks [9, 10, 11], modelling tools [12, 13], the emergence of landscape sustainability science [14] and new questions about the role and contribution of science, in particular landscape ecology, to transition towards sustainability [15, 16].

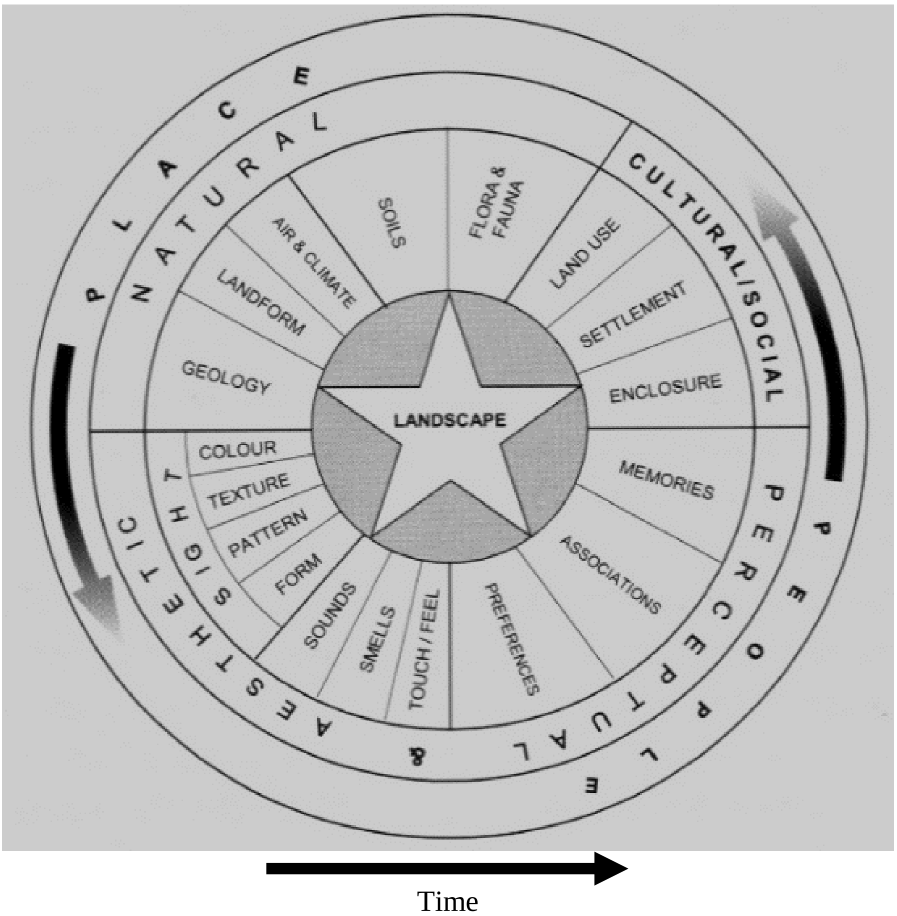

Fig. 1. Landscape results from the way that different natural, cultural, social, perceptual and aesthetic component, such as geology, soils, climate, land use, sounds, smells, etc. interact and are perceived and imagined by people over time (Source: Swanwick and Land Use Consultants, 2002)

Since sustainable landscape development is a normative goal, decisions, aiming to make a landscape more sustainable, depend on values, worldviews, knowledge and resources available. Therefore, to make decisions about sustainable landscape development requires ongoing societal processes that promote collaboration, learning and open discussions about potential trade-offs between competing landscape interests, values, effects of land use and management changes, and potential consequences for landscapes elsewhere [17]. Importantly, transitions towards more sustainable landscape development requires collective human practice – collaborative planning, management and governance – people talking and working together, trying out new things and feeling new experiences [18].

Materials and methods

2.1 Case study location

The Trebon Basin is located in South Bohemia in the Czech Republic, covering an area of about 700 square kilometres with an altitude between 410 and 550 m above sea level. The region is moderately warm with a mean annual temperature of 7.8°C and annual precipitation between 600 and 650 mm [19]. The landscape is characterized by a large-scale system of fish-ponds, canals, and peat bogs, extensive coniferous forests, meadows, and some arable fields. The Luznice is the main river in the basin, which drains the area and part of the adjacent Austrian territory, flowing north towards the Vltava and Labe Rivers. The name of the basin originates from the central town in the basin, Trebon. The region is one of the most popular tourist destinations in the Czech Republic bordering Austria in the South [21].

2.2 Case study analysis

We took an integrated retrospective and prospective approach to assess the landscape of the Trebon Basin with the aim to uncover if and how the cultural heritage features in the Trebon Basin, i.e. the artificial fishponds and lakes that were mainly built in the 15th – 16th century, contribute towards sustainable landscape development. We based our analysis on historical records, including maps and photographs, and literature on the Trebon Basin, including scientific papers, reports, statistics, and webpages. In addition, we used participant observation and information gathered during numerous field trips with students in the case study area to complement our analysis.

Results and discussion

3.1 History of the Trebon Basin

Before human settlement the Trebon Basin was considered a hostile marshy landscape [22]. In the 12th century, the first settlers arrived and began to modify the landscape. During the 13th century, the first fishponds were built by the Cistercian Order and the Order of the German Knights to provide carp during Lent. However, it took until the 14th century when the dynasty of Rozmberk, a powerful Czech royal family of the high Middle Ages, brought prosperity to the region and supported the building of fishponds on a large scale. The Golden Canal, which forms the backbone of the entire Trebon pond system, was built between 1506-1520 and is 45km long and has a descent of only 32 metres. The building of the Trebon fishpond system continued and experienced its greatest expansions during the 16th and beginning of the 17th century. The biggest fishpond, named after the Rozmberk, was built at the end of the 16th century north of Trebon and could easily be considered a large dam rather than a fishpond. Fish farming became very successful and by the beginning of the 17th century reached its height.

In 1883, the first spa opened in Trebon, where various ailments were treated using the peat from the surrounding area. However, only in 1960, Trebon received the status of a spa town.

In recognition of its natural and cultural values, the Trebon Basin was designated a UNESCO Biosphere Reserve in 1977, and declared as Protected Landscape Area at national level in 1979 [23]. The Trebon fishponds and peatlands, which are part of the core area of the biosphere reserve, are also listed as wetlands of international importance within the Ramsar Convention (Fig. 2 Left and Right) [23]. These were designated 1990 and 1993 respectively. About 15% (of the total area of 700 square kilometres) of the biosphere reserve is covered by water forming and extensive system of fishponds (shallow artificial lakes), which are interconnected by canals and ditches (Fig. 2 Left).

Fig. 2 Left: View of the Trebon Basin biosphere reserve. Right: Peat bog in the Trebon Basin biosphere reserve. Photo credit: PLA Adm. Miroslav Hatle ©.

Further habitats of particular conservation value include various types of wetlands, including fishpond littoral zones with reed and sedge belts, floodplain swamps and forests, marshes, alder and willow carrs, wet meadows, peat bogs, acidic fens and sand dunes. Species native to both the northern tundra and warm continental lowlands, as well as species associated with extremely wet and dry biotopes live in close proximity in the Trebon Basin. The biosphere reserve is also classified as European Important Bird Area (IBA), providing habitat and food sources for nesting and migratory birds, including ducks, geese, bitterns, black storks, and the white-tailed eagle. In addition, the biosphere reserve is also the core area of the Czech otter population [23].

Also in 1977, the Trebon Basin was included in the international network of Long-Term Ecological Research (LTER) sites, due to its exceptional biodiversity values. In addition to extensive biodiversity and ecosystem functioning research, multidisciplinary studies, involving discussions between different stakeholder groups, have also been carried out during to the early 1970s [24].

After the Velvet Revolution, a largely non-violent transition of power from communism to a democracy, which occurred in late 1989, the textile factory Otavan, which was, at the time, the largest employer in Trebon, went bankrupt. Since then fish-farming, agriculture, mining, and tourism are the main income generating activities in the Trebon Basin.

3.2 Current uses of the Trebon Basin

The Trebon Basin is still the main fish-farming centre in the Czech Republic today and the largest producer of fresh water fish in Europe [22]. The fishermen manage about 380 fishponds and harvest around 3,000 tons of fish, produced in the basin, every year (Fig. 3 Left). Ninety-five percent of the production is carp, making this the traditional fish and one of the symbols of the Trebon city.

Every autumn, traditional scenes can be witnessed in the Trebon Basin when the fishermen fill their nets with fish (Fig. 3 Left). This has happened for a past 400 years and has become, besides a social event for the local communities, also an interesting tourist attraction [22].

Besides commercial forestry, arable crops – for food and biogas energy production – are grown in the Trebon Basin. From some of the meadows, grass silage is produced as energy crop to feed the biogas plant, located 2 km north of Trebon [25]. The biogas plant supplies heating to the spas and associated facilities in Trebon and received the award ‘The Czech Energy and Environmental Project of the Year 2009’.

In addition, several exploitive activities, including large-scale extraction of peat, quaternary sand and gravel mining, are carried out. Several mine sites also serve as study locations for research projects, focused, for example, on lakeside vegetation, amphibians, and water bugs [26]. Collaboration between a mining company, researchers, and the Administration of the Trebonsko Protected Landscape Area led to the maintenance of a steep slope at a lake bank for nesting Sand Martins (Fig. 3 Right), maintenance of initial stages of succession, and areas left to develop naturally after mining ceased.

Fig. 3. Left: Autumn fish harvest in the Trebon Basin. Photo credit: Archiv Vydavatelství MCU s.r.o ©. Right: Lake bank maintained as a steep slope for nesting Sand Martins. Photo credit: The Quarry Life Award project ©.

Due to the relatively flat terrain, its cultural, aesthetic and conservation values, the Trebon Basin is ideal for walking and cycling. Many walking and riding trails have been established around Trebon, many of which are educational, informing visitors about natural wildlife, cultural heritage, technical points of interest, rural architecture, and more. Further recreational activities include water sports, such as canoeing and angling, mushroom picking, and hunting. The main influx of tourists takes place during the summer months, when the ponds, sandpits, lakes and streams provide suitable temperatures for swimming. Forests are also attractive recreational sites and are visited mainly on summer and autumn weekends by hikers and bilberry pickers. In addition, the Trebon spas provide an ideal place to relax, swim and get well.

The Trebon Basin also remains an interesting study area for scientists and educators from a wide range of disciplines. While some university professors take their students on regular field trips to the Trebon Basin to study “one of the best examples of sustainable landscape development in the Czech Republic despite its challenges” (pers. com.) others promote the development of a Trebon Basin long-term social-ecological research platform to replace the local LTER site through their research activities [20, 27].

Echoing this view, some commentators have noted that the Trebon Basin differs from other protected areas in the Czech Republic and Europe, because of the harmonious relationship between nature and human activities in the landscape, making it a perfect example of ‘sustainable landscape development’ based on successful human interventions into natural processes [28]. However, this new long-term balance between nature and human society seems to have been distorted since the second half of the 20th century when the historical landscape started to become degraded [28]. It appears that the functioning of the landscape has become increasingly threatened under socialist large-scale and intensive production and continues to be after 1989.

3.3 Threats to and challenges faced by the Trebon Basin

Pressures the Trebon Basin currently faces include intensive fish-farming, large-scale peat extraction, sand and gravel mining, biogas energy production, and high concentrations of tourists in some areas. Another significant threat to the landscape is increased soil erosion and contamination of ponds by erosive wash, resulting at least partly from the increase of field size, which took place between the 1950s and 1990s, and from subsequent loss in landscape vegetation features such as hedgerows and copses [29]. Intensive fertilization of nearly five hundred fishponds ranging from 0.1 to 700 ha cause pond eutrophication, extreme fluctuation of oxygen and pH levels, excessive algae and cyanobacteria development, and increasing levels of nutrient loading to the surrounding landscape [30]. Mining activities, which concentrate along watercourses, threaten some of the most valuable local ecosystems and intensive land management practices for biogas energy production jeopardize ecosystem processes crucial for biodiversity conservation.

While the farming and mining activities threaten also the tourism and recreational potential of the area, tourism and recreational activities put additional pressure on parts of the region, particularly on vulnerable ecosystems [21].

To moderate some of the challenges presented by competing interests and values, the Trebon Basin Biosphere Reserve and Protected Landscape Area Administration promotes the idea of sustainable fishfarming [31] and supports compensation payments for economic losses caused by conservation measures in addition to traditional legal instruments. The negative impact of landscape structure is gradually mitigated by land consolidation and other landscape planning projects, which facilitate the re-introduction of landscape vegetation and contribute to creating new, smaller agricultural fields.

3.4 The Trebon Basin: a social-ecological dynamic system

Conceptualising the Trebon Basin as a linked social-ecological dynamic system that evolves over time facilitates a more holistic, integrated analysis of potential trade-offs between competing landscape values and supports community participation. In addition, it allows asking the question what ‘sustainable landscape development’ may mean in the Trebon Basin today and in the future. Events such as the extreme floods that occurred in the area during 2002 and 2006 provide a timely reminder of the essential role of the large-scale fishpond system and the semi-natural wetlands to mitigate not only floods in the area but also to protect downstream regions from flooding, including Prague.

Considering the multiple values associated with this phenomenally engineered large-scale system of ponds, it is not surprising that the Trebon Basin is celebrated as an inspirational example of sustainable landscape development. However, the pressures and challenges described above, may require new approaches from the bottom-up to re-define sustainable landscape development in the Trebon Basin and to safeguard the values held dearly by the local communities living in and managing the landscape [32]. Collaboration between the different stakeholder groups including local communities, industry, government, conservation organisations, and researchers, will support joint learning about potential trade-offs, interests and values associated with Trebon Basin and underpin more informed landscape management and policy decisions.

Conclusions

We analysed the historical development in the Trebon Basin in the Czech Republic, and argue that this phenomenally engineered large-scale system of ponds has survived into the 21st century due to its multiple values, including economic production value from aquaculture, recreational opportunities, biodiversity, cultural and aesthetic values, and its potential to mitigate floods. To address current threats to and challenges facing the Trebon Basin we propose new strategies based on collaboration, joint learning and open discussion amongst the different stakeholder groups on equal terms. This will underpin more informed landscape management and policy decisions aiming to support sustainable landscape development into the future.

Acknowledgements

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MAIN FACTORS OF SPATIAL LANDSCAPE PLANNING IN SAMTSKHE-JAVAKHETI REGION

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Abstract

The paper presents Spatial-Territorial Planning issues of Tourism and Recreation Cluster of Samtskhe-Javakheti region, one of the most outstanding regions in South of Georgia. This region include 6 protected areas, 14 resorts and 13 resort places; numerous cultural heritage monuments, including cultural landscape; the wide part of the territory is covered by coniferous forests; and is crossed by the highways of international and national significance. The paper aims to define the role of the regional landscape in the spatial-territorial planning process.

Despite all above-mentioned advantages, Samtskhe-Javakheti region is one of the economically weak regions of Georgia. The main objective is to define spatial planning tools, which will contribute to the social, economic, environmental and cultural components of the sustainable development, including intangible cultural heritage as a new approach to protection system of cultural heritage as a whole. Regional landscapes were investigated using methods of cluster analysis, GIS-analysis, defining spatial layers and prospective recreation areas. Based on the previous researches, recommendations for the strategic vision of the regional development from the point of view of the spatial-territorial planning were elaborated.

One of the main recommendations is to consider the traditional Meskhetian Know-How of terraced arrangement of the landscape, used in agriculture and construction, under contemporary conditions. Terraced arrangement method of the landscaping can be defined as intangible heritage monument (Fig.1).

Key words: landscape planning, intangible cultural heritage; tourism and recreation cluster, spatial-territorial planning, regional development, ecology.

Introduction

Samtskhe-Javakheti is a southern region of Georgia, historically contained provinces of Tori, Samtskhe and Javakheti, bordering with Turkey and Armenia. This beautiful region encompasses six municipalities: Adigeni, Aspindza, Akhalkalaki, Akhaltsikhe, Borjomi and Ninotsminda.

Fig. 1. Meskheti terraces near Vardzia
(Photo: T. Khoshtaria, 2018)

Considering the concentration of resorts and resort places, this region could be compared to the resort group of the Black Sea coast of Georgia. The majority of the resorts of Samtskhe-Javakheti, 9 resorts and 7 resort places are located in Borjomi municipality [1].

The numerous healing mineral and thermal water springs, up to 500 cultural heritage monuments of different epochs: ancient, medieval, past centuries and between them, popular in last time engineering heritage monuments; picturesque landscapes and natural monuments of the several protected areas as Borjomi-Kharagauli National Park, Javakheti protected areas etc., are building a rich recourse potential of this region.

Largest of these protected areas is Borjomi-Kharagauli National Park, founded in 1995 around existing from 1936 Borjomi Nature Reserve [2][3]. Region of Samtskhe-Javakheti, with its picturesque landscapes, protected areas, cultural landscape, resorts, rich and diverse cultural heritage, agricultural lands, natural potential as forests and mineral waters, can be characterized as "Region of Resorts". Tourism and Recreation Cluster of Samtskhe-Javakheti is considered as a geographic concentration of resorts, resort places, protected areas, nature monuments, cultural heritage, and territories with unused health-care potential, and can be presented as following sub-clusters:

1. Tori: Mountainous and sports, also climatic-balneology sub-cluster;
2. Samtskhe: Akhaltsikhe-Abastumani-Aspindza balneology sub-cluster;
3. Samtskhe: Akhaltsikhe-Abastumani educati-onal-cognitive sub-cluster;
4. Javakheti: Aspindza-Akhalkalaki cultural landscape sub-cluster;
5. Tori-Javakheti: Eco/cultural tourism sub-cluster of Javakheti and Gujareti valley (Fig.2).

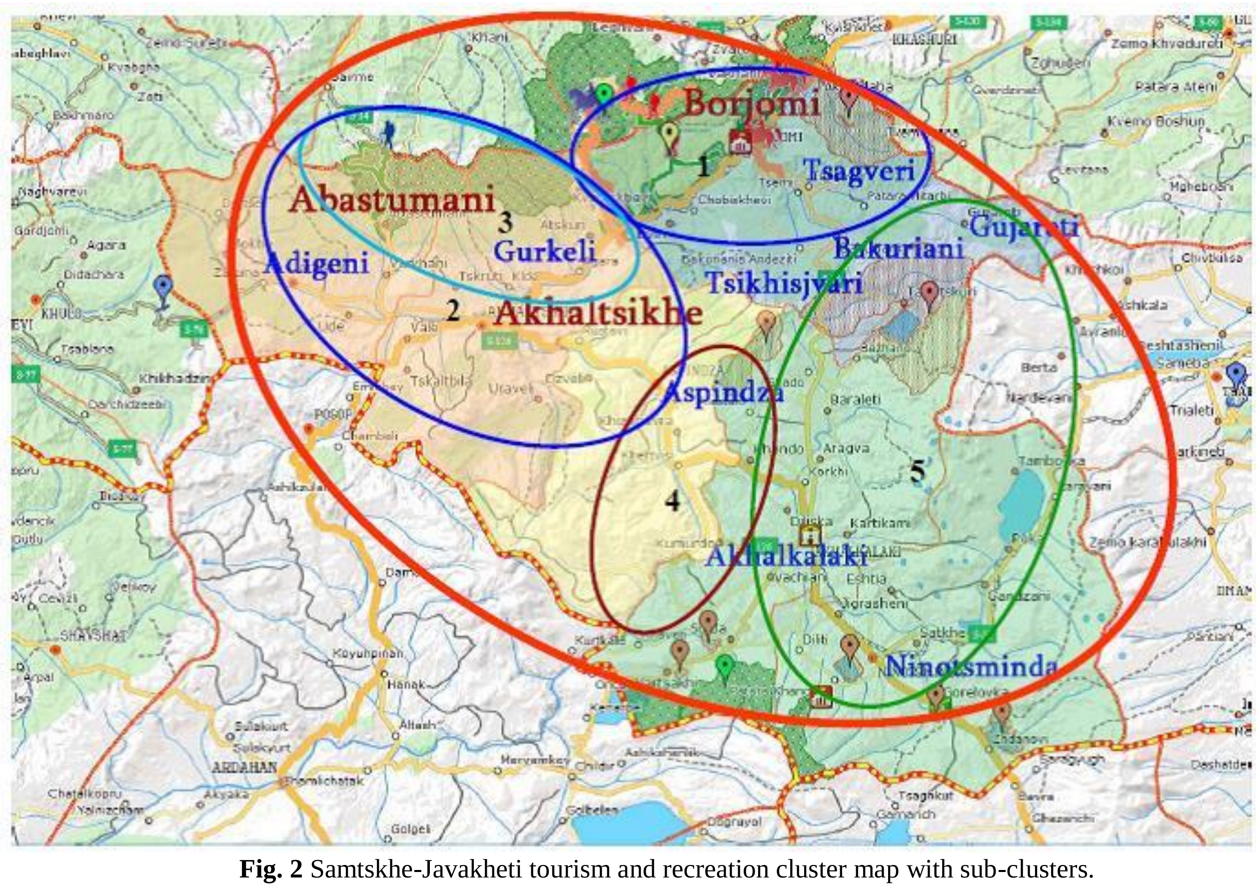

Fig. 2 Samtskhe-Javakheti tourism and recreation cluster map with sub-clusters.

As known from definition of M. Porter: "Clusters are geographic concentrations of interconnected companies and institutions in a particular field" [4]. Due to the new economical approaches of the clustering and spatial economy, the settlements should use their competitive advantages to achieve the sustainable development results [5]. To define these advantages and appropriated spatial planning policy, many directions, branches and aspects should be analyzed. Between them are locations of the settlements, natural conditions, geo-spatial layers, road system, cultural heritage monuments, natural resources etc. In addition, development-hindering factors as ecological problems and natural disasters should be investigated.

Between others, as one of the outstanding peculiarities of Samtskhe-Javakheti Regional landscape can be considered its ancient and medieval terraces. Terraced arrangement Know-how reveals the local cultural approach of the one of most mysterious and interesting Region of Georgia. These terraces and terraced dwellings have status of material cultural heritage monuments with different values – national and local. Most of artificially terraced landscapes of Samtskhe-Javakheti are concentrated in the area of KhertvisiVardzia-Oloda Cultural Landscape (Fig. 3) [6].

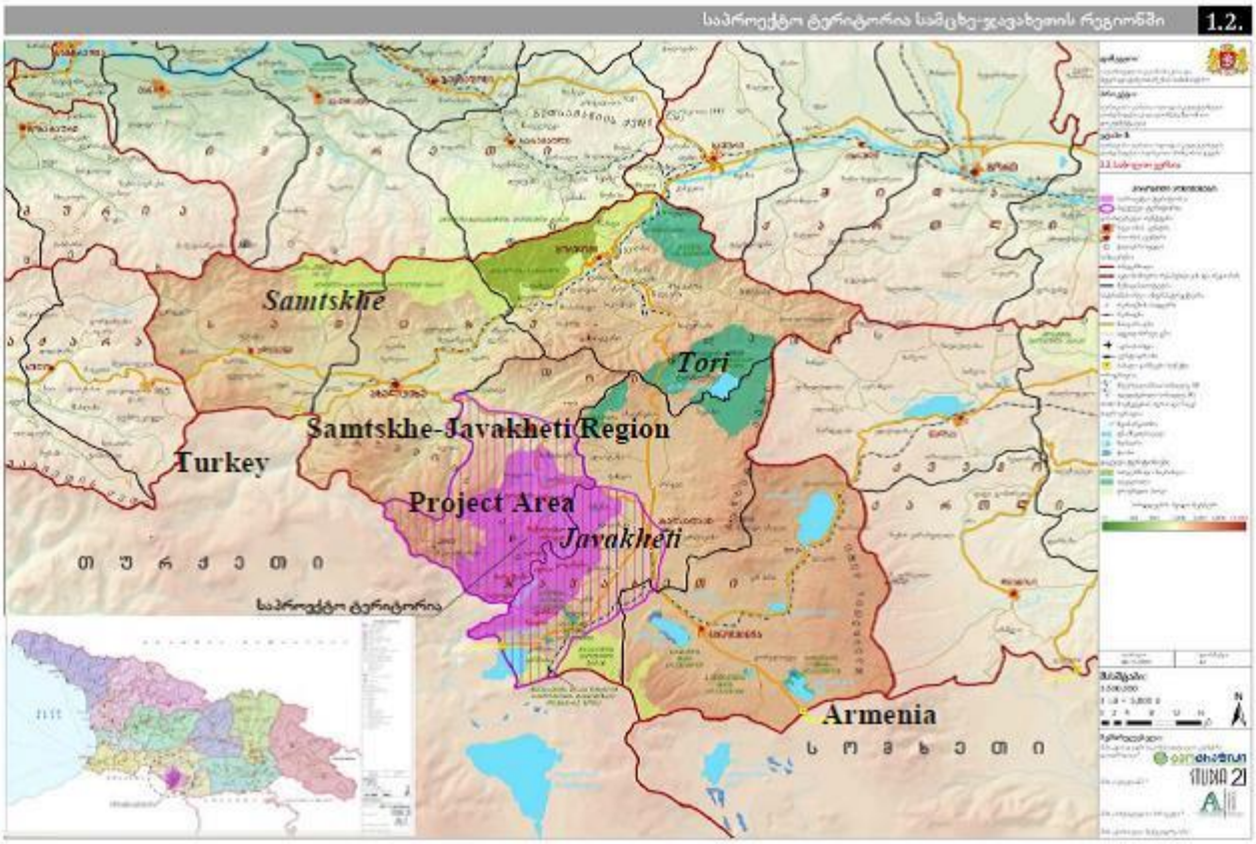

Fig. 3. Khertvisi -Vardzia-Oloda cultural landscape project area.
GIS&RS Consulting Center Geographic, 2015 [6]

Objectives

This paper aims to define regional spatial landscape planning strategy of Samtskhe-Javakheti; to analyze the spatial-territorial planning issues of the region using appropriate methods and tools; to reveal the terraced landscaping Know-how as an intangible cultural heritage of Georgia.

Material and methods

Spatial-territorial planning documentation, elaborated for Samtskhe-Javakheti region, was analyzed. As investigation methods were used: clustering, GIS-analysis, cartographic analysis of geo-spatial layers, comparative and critical analysis, spatial-territorial planning tools.

Discussion

The Tourism and Recreation Cluster of Samtskhe-Javakheti can be presented as a scheme of interconnected resorts and resort places (Fig. 4.) As it is mentioned on the Fig. 4, resorts and resort places are mainly concentrated in the Northern and Western areas of the Region.

These areas can be defined as balneology, climatic, sports, educational, ecotourism and recreational zones. Due to the natural conditions of Gujareti valley and Javakheti protected areas, Southern and Eastern landscapes of the Region can be considered as mainly ecotourism zones, what is easy to conclude, analyzing geospatial layers of the Samtskhe-Javakheti region.

Considering natural conditions, it is obvious that in the southern area, called Javakheti, land cover does not show the green and forested territories as in northern municipalities. Maybe this factor was one of the reasons that terraced landscapes were developed there.

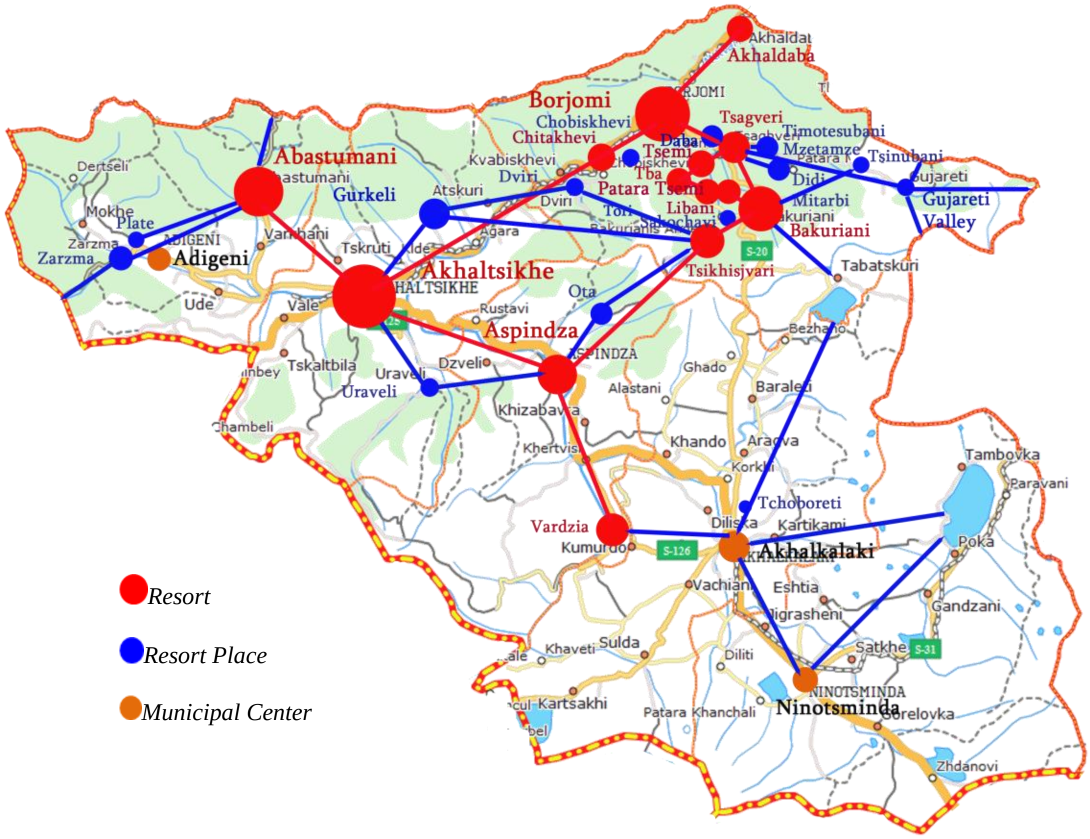

Fig. 4. Map of Samtskhe-Javakheti. Functional relation of resorts/resort places of tourism, and recreation cluster.

Generally, the similar terraces are very often to found in South of Georgia. For the areas with less green coverage terraced landscaping has several advantages: helps to distribute water flows from the mountains evenly on the soil and in this way offers a good condition for the growth of plants; helps to prevent heavy rain flows to the settlements which are located in mountainous terrain between slopes[7]. This method is friendlier to the natural landscape appearance also in case of construction.

Several geo-spatial layers of the regional landscape were used for the physical analyze of Samtskhe-Javakheti:

(1, 2) Road network of international and national importance;
(3) River network;
(4) Protected areas;
(5) Green areas;
(6) Resorts and resort places (Fig. 5).

Spatial-territorial planning and arrangement of the Region is fragmental, as in whole Georgia. Although, Samtskhe-Javakheti is in better condition when some regions, having no documentation at all.

Several projects of Spatial-territorial planning documentation were elaborated for resort settlements of Samtskhe-Javakheti:

- Land Use General Plan for Bakuriani ski-resort (was updated 3 times – in 2006, 2009, 2017);
- Land Use General Plan of Borjomi City (2007, Borjomi Municipality project was elaborated partly);
- Land Use General Plan of Abastumani (2008); Land Use General Plan, Development Regulation Plan and Development Regulation Rules of Abastumani (2019) are under elaboration (GIS and RS Consulting Center "Geographic" and Colliers International).

- Development Strategy for Sustainable Development of Abastumani (2015);
- Khertvisi-Vardzia-Oloda Cultural Landscape project, trans-municipal project, comprising areas of Aspindza and Akhalkalaki municipalities (2015) (Fig. 6);

These projects were elaborated by or with a participation of GIS and RS Consulting Center “Geographic”.

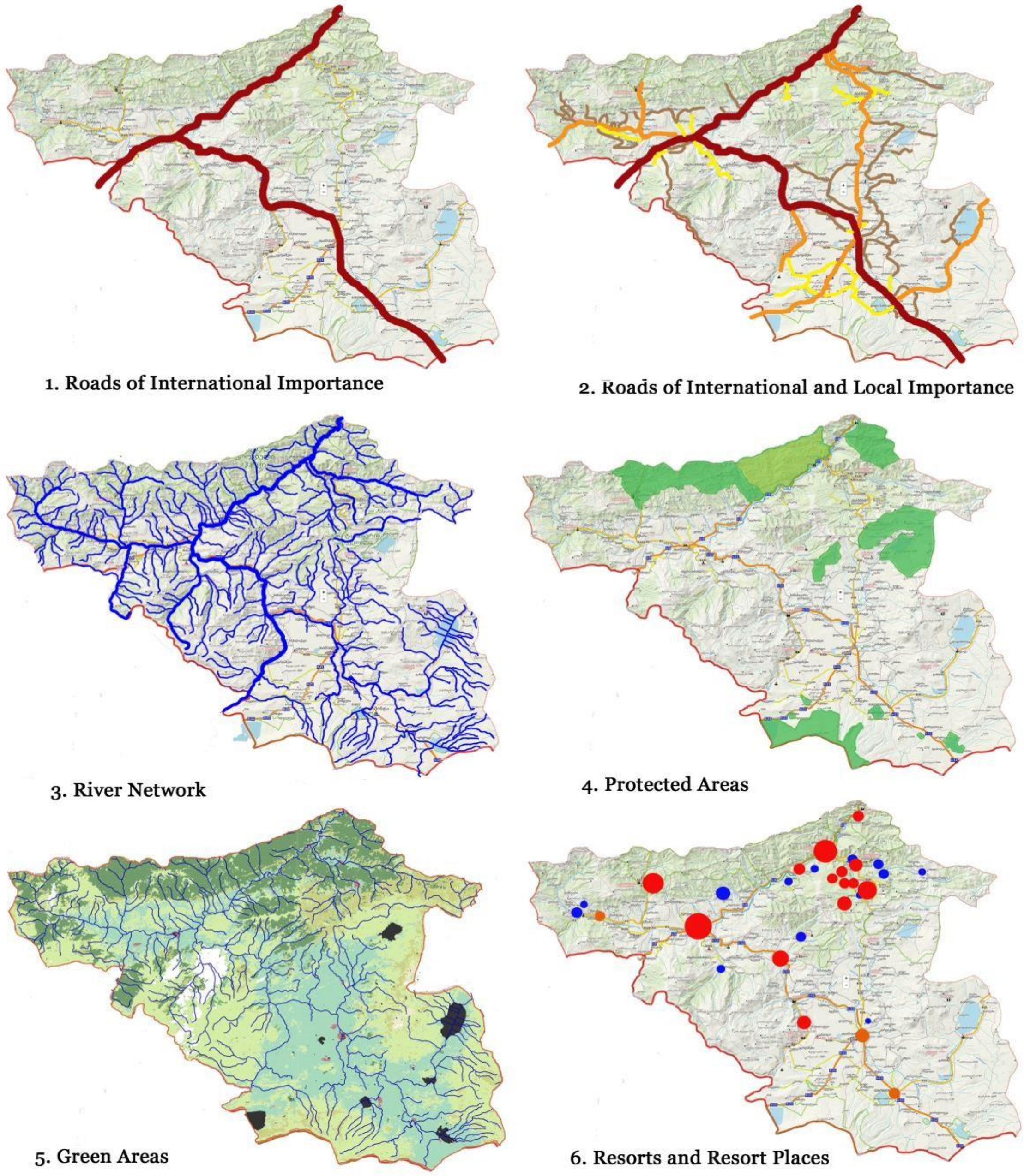

Fig 5. Spatial layers of the Samtskhe-Javakheti region [8]

As the European Landscape Convention declares, “..The landscape contributes to the formation of local cultures and that it is a basic component of the European natural and cultural heritage” [9].

Between different spatial planning factors, the main focus of this paper is directed to the Samtskhe-Javakheti terraces.

Arrangement of the artificial terraces began in the ancient times. The culture of terraced arrangement of the landscape in Georgia belongs mainly to local population of Meskheti, the big part of which suffered during invasions in medieval time. After these times and in particular, after resettlement of Meskheti people before II World War the tradition of terraces was lost and terraces were abandoned. From 70ies of XX

Century interest of the researchers and State bodies to the Meskhetian terraces increased. Mekhetian terraces were investigated byScientific-Industrial Department of History, Culture and Natural Monuments Protection and Use. Importance of terraces was revealed also by the fact that for the description and rehabilitation of the Meskhetian terraces were selected the teachers and students of the leading educational and scientific institution of Georgia, Vakhushti Bagrationi Institute of Geography.

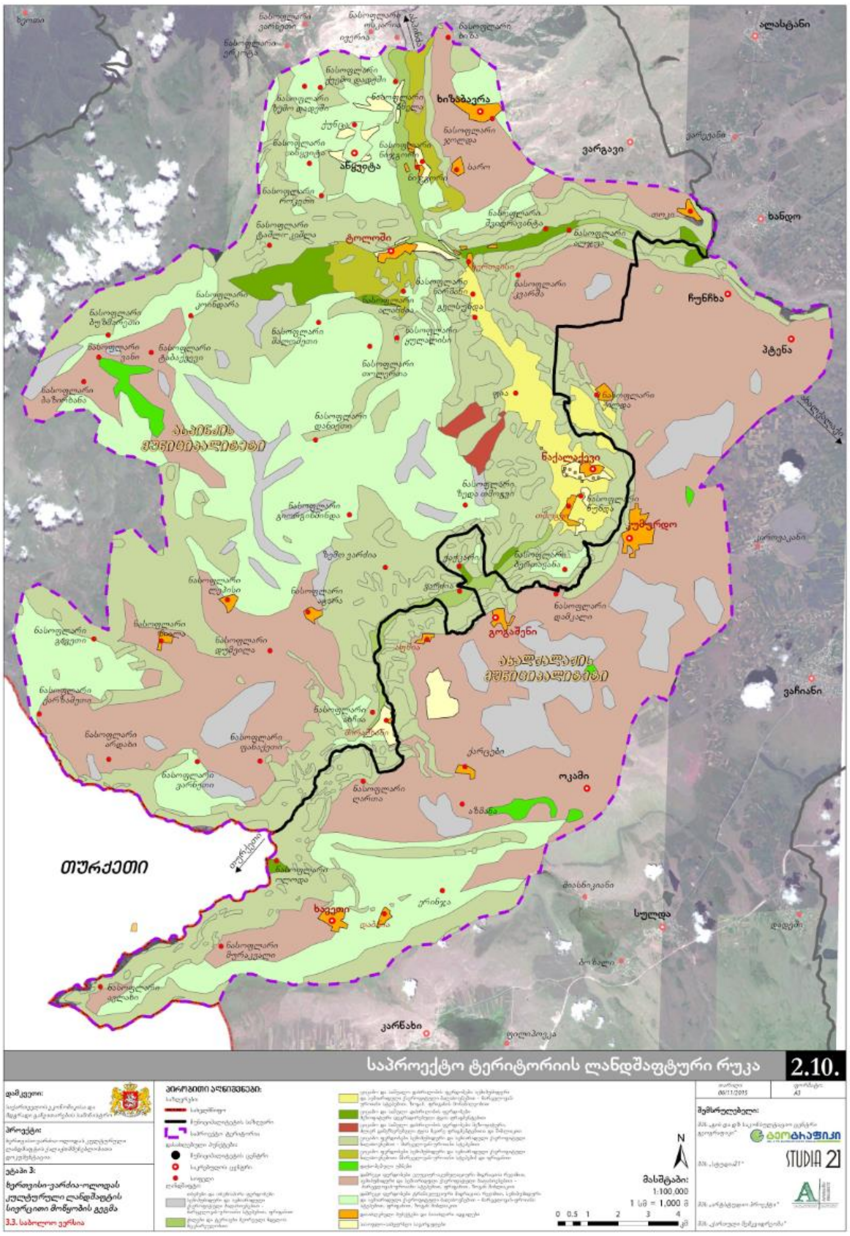

Fig. 6. Khertvisi-Vardzia-Oloda cultural landscape map [6].

Terraced landscapes, used for agricultural purposes, are widely spread in the world. Meskhetian Terraces as outstanding feature of South-Georgian landscape in Samtskhe-Javakheti region are high valuable part of the cultural landscape.

One of the best examples of these monuments is medieval village Tchatchkari, dated from ancient times to XIX C., which was defined as architectural/landscape cultural heritage monument in 2015, by order of General Director of Cultural Heritage Protection Agency of Georgia №2/360 (Fig. 7, 8) [10].

In 2016, Tchatchkari terraces and dwellings rehabilitation project was elaborated (NPLE "Engineering Idea") [12] (Fig. 9). At the same time Vardzia wine terraces rehabilitation near Khizabavra (Natenadze vineyards) began. Historical preconditions of terraced arrangement have deep roots in the ancient and medieval time. Cultural heritage terraces, examples as Vardzia terraces revitalization and rehabilitation project of Chachkari dwellings are giving new touristic function to the old historic tradition. So here is the issue to mention, how the tangible cultural heritage performs in intangible and becomes a tradition. Based on the historic cultural approach, the new ideas about terraced planning can be realized. Advantages of terraced planning in medieval time and now are proved by the contemporary approaches of "Green architecture".

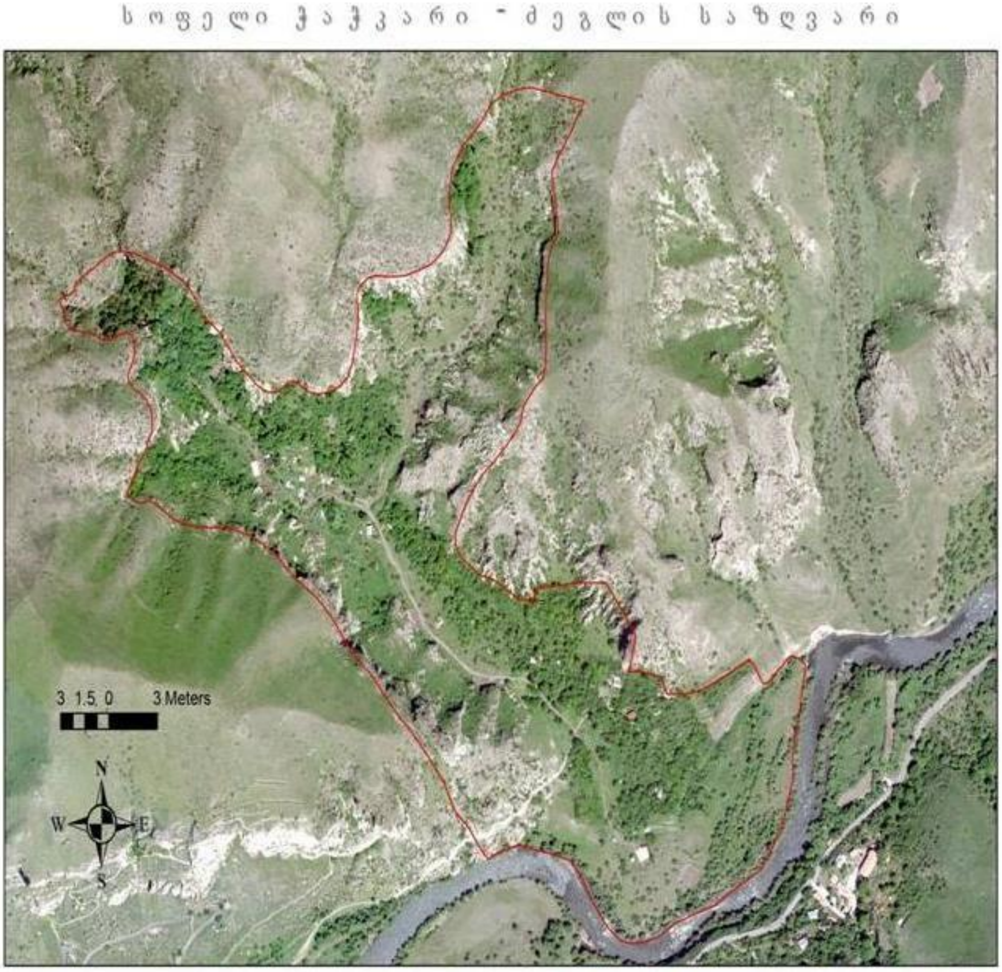

Fig.7. Village Tchatchkari, borders of the monument [10]

Fig.8. Terraced Darani (historic dwelling) in Tchatchkari [11].

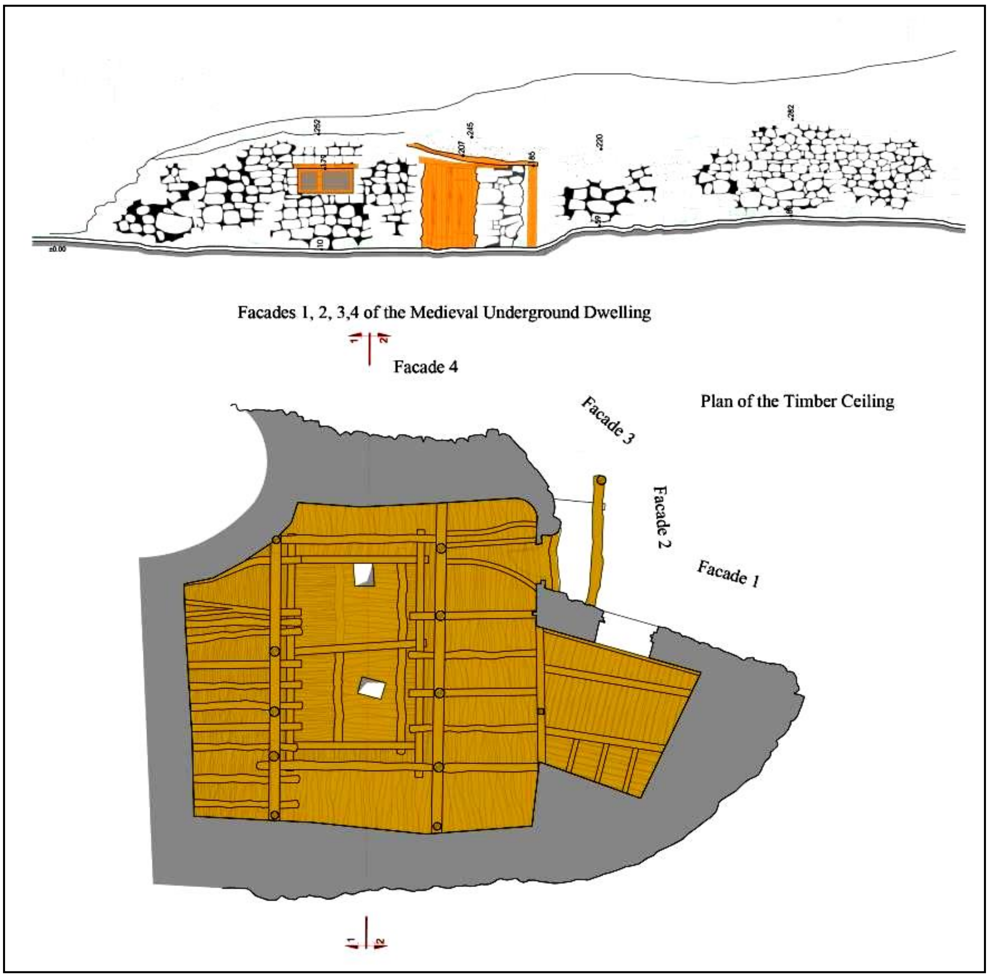

Fig. 9. Medieval Village Tchachkari dwellings rehabilitation project; elaborated by NPLE „Engineering Idea“, 2016.

Generally, the terraced arrangement of the landscape has several functions. Terraces as soil protection method can be found all over the world. They are well known in Mediterranean space and in the Eastern countries. For example, Rice Terraces of the Philippine Cordilleras (Philippines) are in the UNESCO World Heritage list (Fig. 10).

As the official site of UNESCO declares, “Requests the State Party to continuously implement the Rice Terraces Master Plan 2015-2024, including not only the tangible conservation of the property, but also the Ifugao practices and intangible cultural heritage associated with it” [14].

In south of Georgia, in historical Meskheti province different types of the terraced arrangement Know-how can be mentioned:

- Simple, as a landscape forming method for agricultural use, without walls (Larebi) [15];
- Reinforced with natural stone walls, historically used for viticulture in mountainous places, named “Dariji”;
- Housing and other terraced buildings in Meskheti, named “Darani” [16].

In this study two cases of historical terraced arrangement of the landscape is mentioned: “Dariji”, “Khizabavra terraces” and medieval village Chachkari with terraced buildings on the way to Vardzia cave complex, outstanding cultural heritage monument, which is mentioned in UNESCO tentative list since 2007. “Khizabavra terraces” were rehabilitated in 2015 and already in 2018 first “Rtveli” on the historical terraces of South Georgia, Aspindza municipality of Samtskhe-Javakheti region was implemented. Chachkari village belongs to the same region and same municipality and was also renewed.

So, due to the contemporary conditions, when tourism and recreation became one of the biggest industries of the world, this Know-How can be used under renewed conditions and can be recommended for new approaches of the planning and construction as well in forest and landscape management.

Fig. 10. Rice terraces of the Philippine Cordilleras (Philippines). 2004.
Author: Patrick Venenoso. Copyright: © Patrick Venenoso[13]

Fig. 11. Kheoti village in former Meskheti province, contemporary Turkey. Photo: Buba Kudava.
Source: Journal Uplistsikhe, N1. 2011 [18]

Terraced planning/arrangement of the landscape [17]

From the 60-70-ies of the XX century, intensive construction process of the resorts was implemented in Samtskhe-Javakheti. Construction of housing and resort facilities of the Soviet period was characterized mainly by multy-storey buildings. Terraced constructions were almost ignored, probably, because of the technical problems.

Although, the planning and construction of the terraced buildings was taught but this kind of projects were realized, very seldom. In meantime, in the modern international examples of Green architecture this planning tool becomes more and more popular. Terraced buildings, as was mentioned above, are typical for Samstkhe-Javakheti, known as “Meskhetian Dariji” (agricultural terraces, mainly for viticulture) and “Darani” – the type of terraced dwellings, which can be found in historical settlements: Tchatchkari, Kheoti (now in Turkey), adjacent to Vardzia etc. (Fig. 11) [18].

Tradition of the terraced planning in Samtskhe-Javakheti should be considered in rehabilitations and new buildings. Use of historic tradition and modern Green planning approaches can bring interesting results. Considering these factors, it is recommended to use terraced planning tools for different purposes:

- Landscape planning [19];
- Terraced green planting for the settlements, located between mountain slopes;
- For the protection from heavy rain flows and mudflows [17] [20].

The planning of terraced built areas should be performed as much as possible nearly to the natural environment.

Why terraced planning? The positive side of terraced planning is a possibility to achieve maximal harmony with terrain, what is depended on creative features of the project planner/designer; in addition, it is a characteristic tool for mountainous places of (south) Georgia. So, the terraced landscape arrangement tradition can be recommended for the intangible cultural heritage of Samtskhe-Javakheti.

One of the postulates of Green Architecture and sustainable planning is usage of local traditions and materials, minimal impact on the natural environment and planning, in particular, landscape planning close to the terrain. As a challenge can be evaluated some technical difficulties as influence of ground water flows, but contemporary water-isolating materials allow to effectively solve these problems. In addition, the building costs can be higher than usual and more land area is required when it would be needed for highstock building.

Conclusions and Recommendations

Considering the Terraced arrangement of the landscape as only the agricultural issue, as it is considered as usual, cannot fully express the whole philosophy of terraced landscape or terraced construction planning. This method reveals the culture, the general approach to the nature – very gentle and natural way for the careful correction of the landscape. The Meskhetian terraced arrangement method is very similar to the contemporary “Green architecture” approaches and can be considered as intangible cultural heritage. So, based on this provision, the main recommendations are:

- To consider Meskhetian Terraced arrangement Know-how as intangible cultural heritage monument;
- To recommend for the future recreational planning/projecting, in particular, for resort planning – design close to nature using “Green architecture and construction” approach; projecting in the way not to damage natural forms of the mountainous landscape;
- As future idea for spatial and landscape planning education programs, for example, for students of the similar direction: elaborate a workshop program/summer school program for the terraced projecting in Samtskhe-Javakheti under contemporary conditions – to find an example place/location, to make a sketch of the real landscape topography and analyze cases of different scale – for spatial planning; for rural areas DRP-s; for building complexes as new hotels and sanatoria; create figures and sketches for each case.

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INFLUENCE OF CLIMATE ON THE BOARDER OF SOILS (ON EXAMPLE OF CINNAMONIC AND BROWN FOREST SOILS OF GEORGIA)

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Abstract

Author has studied the impacts of climate change on the soil in recent years, namely, on their area and the current state on the border of the cinnamonic and brown forest soils. This issue has been studied in the vicinity of Tbilisi. Here used to be the border between the two soils.

The cinnamonic soils are carbonated soils, and brown forest soils are acidic soils. Author explored the 15-year old borderline data between these soils - that is, between cinnamonic and brown forest soils at 1150-1210 meters above sea level. Thus, below this altitude the soil was cinnamonic (carbonated), and above this altitude - brown forest soils (acidic).

Author studied the present borderline between these two soils and found out that it had moved 50-100 meters higher. Presently, the border passes at an altitude of 1200-1310 meters above sea level.

This means that below this altitude the soil is now cinnamonic (carbonated), and above it the soil is brown forest soil (acidic). If such tendency persists, this will result in the disruption of ecological balance of these soils and it will become necessary to review the existing agricultural and forestry approaches and take effective measures.

Key words: Cinnamonic soil, brown forest soil, border, carbonate, acid reaction, alkaline reaction.

Introduction

Cinnamonic and brown forest soils are more or less good investigated. Cinnamonic soils were described in our country for the first time by S Zakharov [1]. He investigated this soil in the surroundings of Mtskheta, on the northern slope of the mountain Didgori in an oak hornbeam forest. Later, he described this soil also in Kakheti, on the Tsiv-Gombori range, in the surroundings of Akhaltsikhe and in other areas.

S. Zakharov distinguished cinnamonic soils clearly from podzols, kastanozems and chernozems, which are widely distributed in the dry subtropics of Georgia. Apart from this, he compared these soils with Ramann's brown forest soil in the South-East of France. Moreover, in the classification of the soils of Georgia, S. Zakharov distinguished them as a subtype of the forest grey (now brown forest) soils. Important investigations of this soil were achieved by M. Sabashvili [2, 3].

I.P.Gerasimov [4] accepted this soil as an independent genetic type and named it cinnamonic soils of dry subtropical forests and shrubs. In our country cinnamonic soils were further investigated by I. Anjaparidze [5], E. Nakaidze [6] and T. Urushadze [7], who described the main properties and peculiarities of these soils through detailed analysis.

In Georgia the brown forest soils were first investigated by 30-s years, but investigations were inexact and mistaken. The brown forest soils could not only be restricted to maintain forests, but to all forests in open areas. The following investigations answered the questions of genesis, geography and classification of brown forest soils [8-10]. It is very important to study the impacts of climate change on the soils in recent years, namely, on their area.

Materials and methods

We have studied the current state on the border of the cinnamonic and brown forest soils. This issue has been studied in the vicinity of Tbilisi. Here used to be the border between the two (carbonate and acid) soils.

The southern edge of Tbilisi is located on the northern slopes of Trialeti Range. The objects were 3 soils profile – on the north upper board of Tskhneti, 1200 m, $15^{O}$and 3 profile – on the south upper board of Tskhneti, 1100 m, 10^{O}.

In soils were investigated content of hydrological water, pH, content of humus and $CaCO_3$ and texture by the adoption methods [11].

Results and discussion

According investigations of brown forest soils (upper board of Tskhneti, 1200 m, exposition north, 15^0) they have alkali reaction (pH=7,7-8,3), carbonates (0,62-5,96) (Tab.1) – as a result we have cinnamonic carbonate soil, but not the brown forest. This soil has a middle loam texture (Tab.2), but this parameter does not have diagnostic meaning.

Table 1.

General analysis

Profile	Horizon, depth, cm	Hygroscopic water, %	pH	Humus, %	CaCO3, %
Upper board of Tskhneti, 1200 m, exposition north, 15^0					
1	A – 0 – 9	4,38	7,7	5,50	0,62
	B – 9 – 30	4,38	8,1	4,11	1,23
	BC2 – 30 - 50	4,38	8,3	3,80	1,54
2	A – 0 – 7	5,26	7,2	9,88	0,12
	B1 – 7 – 25	3,95	8,0	3,87	0,93
	B2 – 25 - 45	4,38	8,2	3,42	2,77
	BC2 – 45 - 65	4,17	8,3	2,64	3,70
3	A – 0 – 8	5,46	7,6	11,52	1,87
	B – 8 – 35	4,82	7,9	6,84	5,91
	BC2 – 35 - 70	5,26	7,8	6,03	5,96
Upper board of Tskhneti, 1100 m, exposition south, 10^O					
4	A – 0 – 8	4,38	8,0	4,46	2,47
	AB – 8 – 15	3,73	8,2	2,36	8,63
	B – 15 - 45	4,17	8,0	1,90	11,09
	BC – 45 - 70	3,73	8,3	1,67	10,79
5	A – 0 – 7	4,38	7,9	5,50	4,62
	AB – 7 – 16	3,73	8,1	2,71	8,76
	B – 16 - 40	3,52	8,3	2,58	9.55
	BC – 40 - 65	3,52	8,3	2,58	10,12
6	A – 0 – 5	4,82	7,9	6,84	1,56
	AB – 5 – 12	4,82	7,8	4,39	1,56
	B – 12 - 40	3,73	8,3	3,36	13,50
	BC – 40 - 70	3,95	8,2	2,17	10,15

Table 2.

Texture

Profile	Horizon, depth, cm	Fractions, mm (%)						
		1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	<0,01
1	A – 0 – 9	5	32	23	7	16	17	40
	B – 9 – 30	8	32	21	8	21	12	41
	BC2 – 30 - 50	6	30	21	7	15	21	43
4	A – 0 – 8	2	16	20	10	18	34	62
	AB – 8 – 15	2	22	19	10	17	30	57
	B – 15 - 45	2	26	19	9	18	26	53
	BC – 45 - 70	3	28	23	5	17	24	46

In other point (upper board of Tskneti, 1100 m, exposition south, 100) we have soils with alkali reaction (pH=7,8-8,3), carbonate 1,56-11,09) (Tab.1) and texture light clay (Tab.2). In this point we have cinnamonic carbonate soils, but not leached carbonate soils as 15 years ago, but cinnamonic carbonate – with carbonate from surface.

Here passes the border between the cinnamonic and brown forest soils. It is well known that cinnamonic soils are carbonated soils, and brown forest soils are acid soils. We explored the 15 year old borderline data between these soils – that is, between cinnamonic and brown forest soils at 1150-1210 meters above sea level. Thus, before this altitude the soil was cinnamonic (carbonate) and above this altitude – brown forest (acid) soil.

We have studied the certain climate indicators using the following approach – the average temperature of 1999 – 201- years was taken and compared with data up to the 1960s. It was estimated that the average temperature of 1999-2010 years was increased by 10-20%. This was a good reason for moving the borderline between cinnamonic and brown forest soils 50-100 meters higher. This regularity is confirmed by the fact that the average temperature at the object of study in January was increased by 100-200%.

Conclusions

The present borderline between cinnamonic and brown forest soils moved 50-100 meters higher. The border passes at an altitude of 1200-1310 meters above sea level.

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AGRO-LANDSCAPE ZONING OF ACHARA-GURIA REGION

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Abstract

The landscape-genetic (complex) method of determining their agro-resource potential is the rational layer of citrus cultures of the Achara-Guria humid subtropical zone and agricultural use of territories. The emphasis has been made on the components that have been substantially impacted (climate, soils, relief) the citrus growth in development and yield. Agro-landscape zoning, which originates in natural geographical zones, implies the allocation of regional agro-geocomplexes of taxonomic ranges that are more or less different from each other: spatial distribution of agro-landscape, hypsometric location, geo-ecological condition, and scale and shape of anthropogenic impact, the level of agricultural use and the nature of agricultural land and the agricultural production is the most important agro-climatic characteristics: SAT, HTC, temperature regime, soil physical-chemical properties and relief conditions (inclination, dismemberment, aspect).

Key words: Agro-landscape, ranking, potential, zoning, agro-climatic characteristics

Introduction

In the presented work it was chosen the 500m elevation zone of Achara-Guria regions. Forests and shrubs have been reduced to less than 500 m in the above areas, resulting in disastrous loss of tea plantations and "unpredictability", which can be eliminated by replacing the new varieties of prospective and high-grade subtropical crops [1].

Agro-climatic index of citrus cultures is considered to be:

- Sum of active temperatures – more than 4000 ^{O}C;
- Minimum monthly humidity balance - 1.0;
- Total annual precipitation – 1600-2500mm;
- Average annual absolute minimums of air temperature -4^{O},
- Coldest month average temperature +4 +7;
- Average annual temperature +14 +15;
- Average temperature of July +22 +23;
- Beginning of vegetation +10;
- Flowering at +17^{O} daily average temperature;
- Frost resistance - 5^{O}-6^{O}.

One of the facts of frost protection is the preparation of the plant for winter that is successfully running, when the temperature of the season is gradually reduced. Additional measures are also required: selection, agrotechnical and ecological. The morphological analysis of the plant implies: height, diameter, general shape, skin and softness color, skin color study, and etc. (Fig. 1).

Citrus cultures adversely affect the east (zena) winds. In winter, the winds of the east rarely affect the vulnerable slopes of the eastern exposition, and in the dry and hot eastern winds in the summer, the fetus has a cleft and fruity, but it is well known that the positive effects of the wind are exposed to excessive moist air and soil drying (Figure 2-3).

The role of Fione may be assessed as negative and positive. The area of the subtropical zone red soil and yellow soils spread on the hills and foothills, which are gradually clearing down to the coast of the seaside and passing along the coastal plains, and in some places the hills move to the sea in the form of capes (Tsikhisdziri, Mtsvane Kontski, adjacent area of Sarpi and etc.). Soil subtropical zone of soils are poor with nitrogen and other nutrition elements. The red soils are mostly distributed in Achara-Guria, also in Southern part of Apkhazeti, Samegrelo (Zugdidi, Tsalenjikha, Martvili). Yellow soils is very common in the Transcaucasia and also are found in western Georgia – in Apkhazeti, Samegrelo and Imereti regions [2; 3].

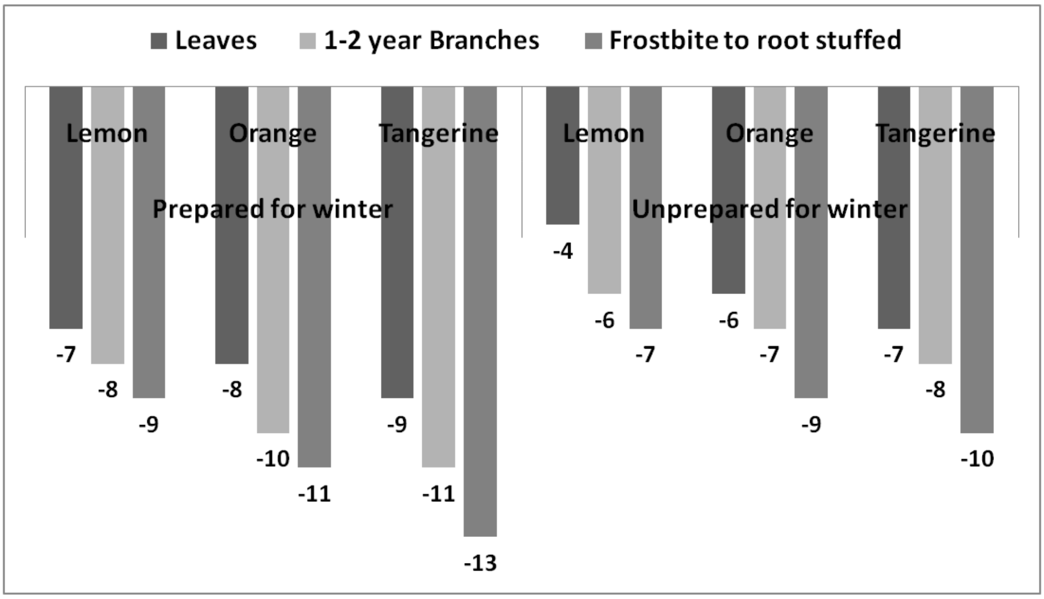

Fig. 1. Critical temperatures (leaves, branches, roots)

Terrain is distinguished by gully-gorges, elevation, inclination and especially aspect (exposure) to citrus development. The south aspect is distinguished by the positive effect in this regard. It should be also taken into consideration the temperature inversions, the cultivation of citruses not only on the slopes of the valley and in the lowlands, but on the slopes of the hillock-fringed foothills, which is often neglected. It is impossible due to temperature inversions in vale areas, it is less severe than winter conditions, although such sections are frequent in the region and the importance of exposure is the most favorable south exposure in this area, where there is a low risk of severe winter conditions. The slopes of the eastern exposure, which are unprotected, are considered to be of high risk from the relatively dry and cold eastern winds. The relatively good condition is the western exposure slopes, as for the north exposition, it is unacceptable for the spread of citrus cultures, although it is suitable for other subtropical cultures – Actinidia, Tung, and others for planting. One of the facts of frost resistance is the preparation of the plant for winter that is successfully running when the temperature of the season is gradually reduced. Additional measures are also required: selection, agrotechnical and ecological. The morphological analysis of the plant implies: height, diameter, general shape, the skin and color of softness, skin color study, and etc.

We calculated the percentages of inclination of the Kolkheti Lowland and the adjacent hills and hillocks and exposure areas, which resulted in the 88% of slopes in the study region with inclination less than 15-25^{O}. While the southern, southeastern and southwest slopes of the “Tangerine-Tiakhara-Ushusu” and “Georgian Saadreo” come from the optimal and favorable south, east and southwest slopes with 40.8% [4; 5]. The best and lowest risk is the southern exposure slopes of hills and foothills. 5-10^{O} slopes can be used without trenching, and the slopes of 15-20^{O} and more are required to create terraces. It should be also noted that old terraces are in need of renewal.

Research Methods

Using a landscape-genetic (complex) method, it is possible to create a scientifically approved basis for anthropogenic transformation, environmental impact assessment, its forecasting, rational nature utilization, environmental protection and conservation.

The characteristics of quantitative-qualitative characteristics of similar geographical objects were made by a comparative analysis method that allowed us to classify geographical objects (typology) and experimental plots.

Using the geographical modeling technique, it was possible to determine the cause-effects of the nature of components, their analysis and synthesis. In the climate modeling laboratory, temperatures are gradually reduced to the ability to freeze citrus cultures.

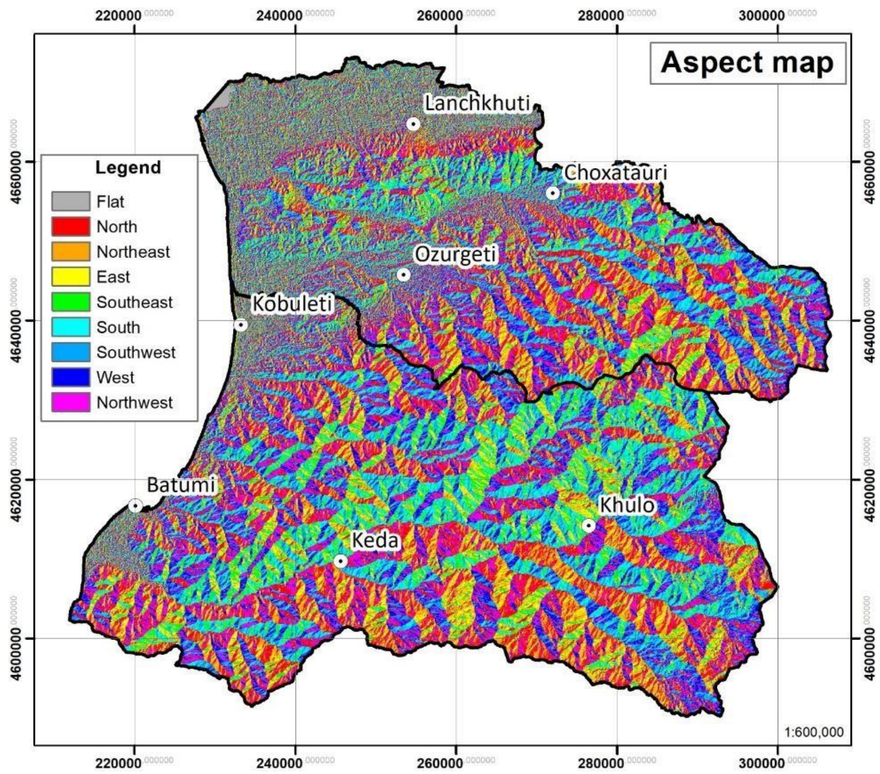

Fig. 2. Aspect map of study area

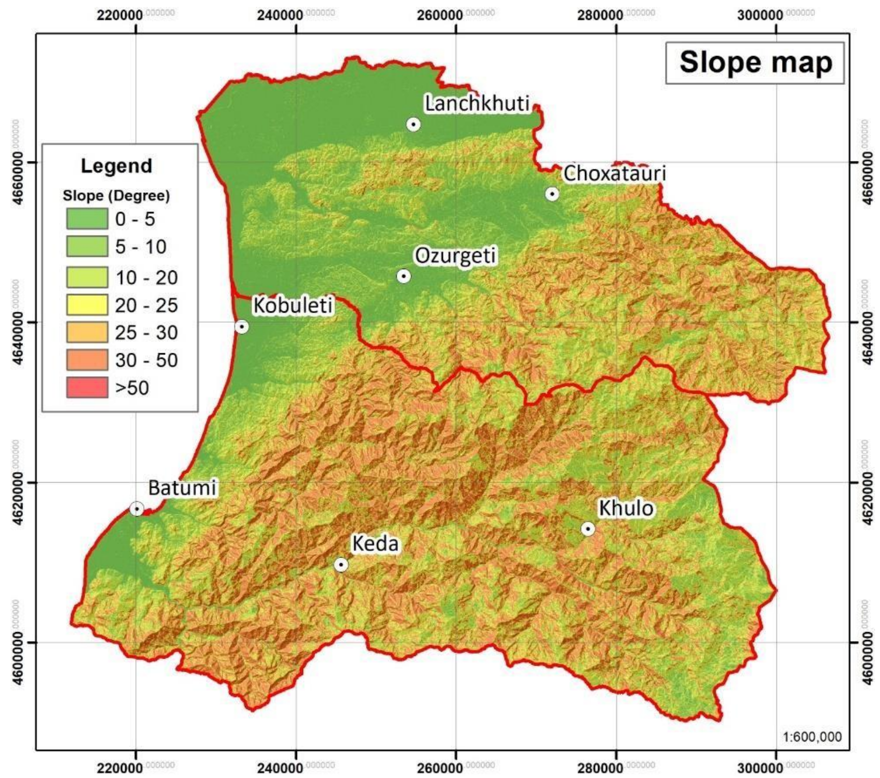

Fig. 3. Slope map of study area

The analytical method has been used to study the main characteristics of the individual parts of the region, and in synthesis, the analysis of the results obtained and the synthesis (compilation) map. Computer technologies (obtaining and processing information, etc.) were used to create geo-information database. Mathematical method was used to determine the weighted average indicators of agro-climatic characteristics, as well as drawing graphs and diagrams.

Achara-Guria region is distinguished for the growth and development of citrus cultures with the most favorable agro-climatic characteristics from the western regions of Georgia. In general, 5 agro-climatic zones are allocated in these regions with only two zones favorable for growth and development of citrus within 50-500 m above sea level [6; 7] (Tab.1):

I zone (50-200m above sea level) - includes coastal regions of Achara with over 4000 ^{O}C sum of active temperatures; number of atmospheric precipitations in the warmest period of 1360-1500 mm; first froze - 2.XII-7.I; last frost - 4.III-15.III; number of days of freezing - 246-304; prevailing soil types – subtropical-edder,red and alluvial;

II zone (200-500 m above sea level) is more extensive and mainly consists of Kobuleti and Khelvachauri municipalities. The sum of active temperatures is 3000-4000^{0}C; number of atmospheric precipitation in the warmest period of 1000-1300 mm; first frost - 6.XII-1.I; last froze - 13. III-26. III; number of days of freezing - 255-273. The prevailing soil type - red and yellow. According to our recommendation, the third agroclimatic zone (500 m to 700 m) for the distribution of frost varieties can be added to Achara region, the average temperature for the coldest month is not below 0, the atmospheric precipitation is 177-2100 mm, the soil type is yellow.

Table 1.

Main Agro-climatic characteristics of Achara region

Meteo-station	Elevation	Sum of Active Temperatures, ≥ 10^{O} C	Amount of ecipitation, mm	Air relative Humidity, %	Air humidity deficiency, mb	Number of Unfreezing days	HTC
Akhalsheni	100	4300	1470	78	5.0	304	3.4
Batumi	15	4320	1440	80	4.7	302	3.3
Keda	290	3880	800	77	5.4	257	2.0
Kobuleti	5	3990	1360	81	4.3	246	3.4
Chakvi	15	4230	1500	80	4.7	282	3.5

The part of western Georgia – Guria is distinguished by subtropical conditions and here is also allocated 5 agro-climatic zoneswith two agro-climatic zones useful for the distribution of subtropical crops (Tab. 2):

I zone (from 30 m to 200 m above sea level) includes coastal and low mountainous areas: the sum of active temperatures exceeding 4000 ^{O}C; number of atmospheric precipitation in the warmest period is 1000-1400 mm; first frost - 16.XII-25.XII; last frost - 10.III-18.III; number of days of freezing - 274-290; prevailing soil types – subtropical, alluvial, red.

II zone (from 200 m to 500 m above sea level), includes Ozurgeti and Lanchkhuti Municipalities, partly Chokhatauri municipality. It is characterized by the following indicators: the sum of active temperatures 4000-3500^{O}C; number of atmospheric precipitation in the warmth of the year – 9000-1200 mm; first frost - 10.XII-20.XII; last frost - 15.III-20.III, the number of freezing days – 250-270; prevailing soil types - subtropical, yellow and red. As a result of consultation with practitioners and agrotechnicians, we managed to process and evaluate agroclimatic indicators for the distribution of subtropical crops, select optimal natural conditions (without aggregation) and land area based on landscape basis.

Table 2.

Main Agro-climatic characteristics of Guria region

Meteo-station	Elevation	Sum of Active Temperatures, ≥ 10^{O}C	Amount of Precipitation, mm	Air relative Humidity, %	Air humidity deficiency, mb	Number of Unfreezing days	HTC
Anaseuli	70	4150	1140	79	4.0	277	2.7
Atsana	160	4020	1130	80	5.0	272	2.8
Dablatsikhe	250	4160	980	74	6.3	272	2.3
Supsa	5	4060	1370	83	4.2	267	3.3
Ureki	10	4380	1180	80	4.6	288	2.7

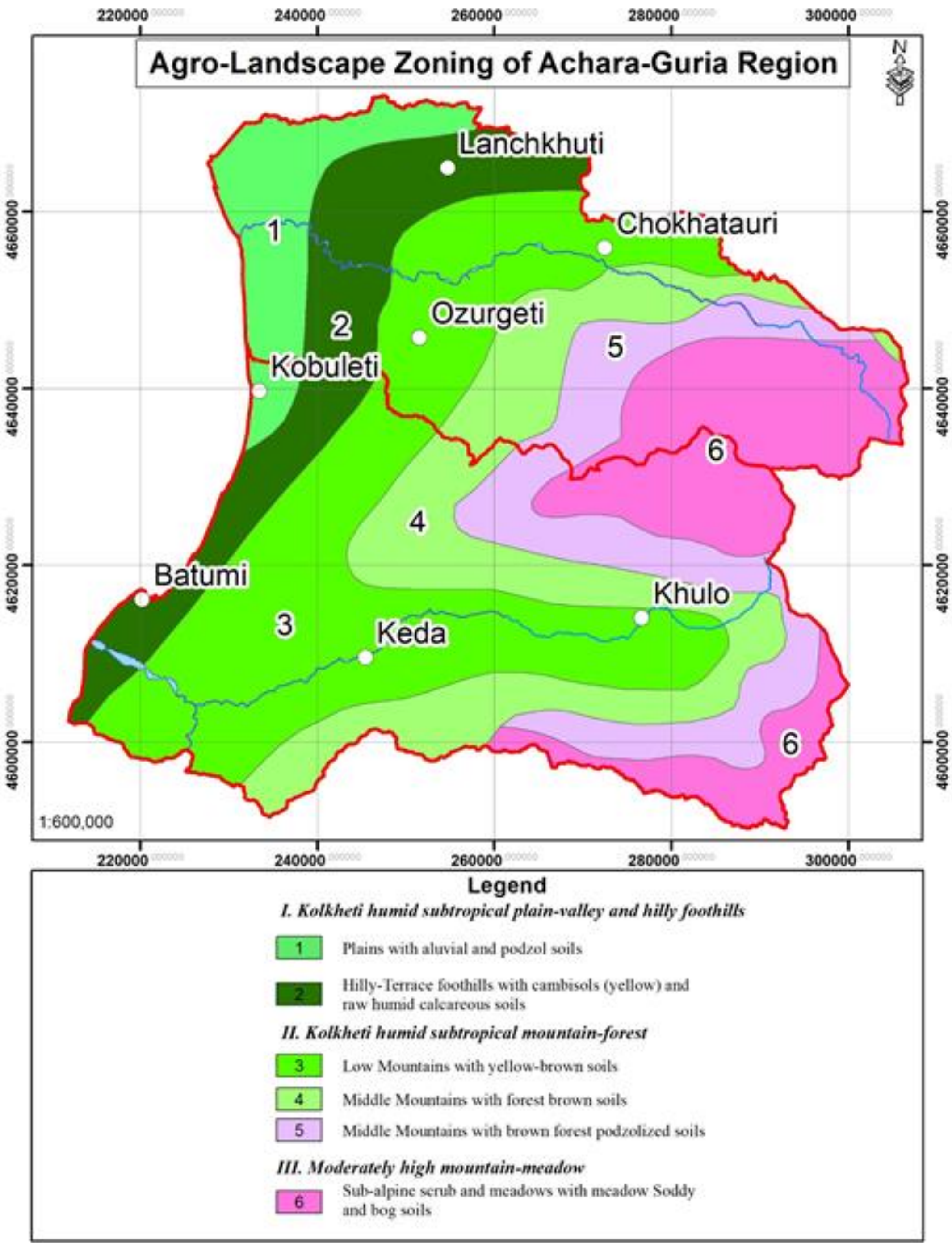

Fig. 4. Agro-landscape zoning of Achara-Guria region

Conclusion

1. Landscape-complex approach has been made to assess and evaluate optimal natural conditions for the spread of some citrus cultures, namely:

a. Calculation of terrestrial morphometric indicators (inclination, aspect) and calculation of areas in % and mapping;

b. Analysis and synthesis of agro-climatic characteristics was conducted.

2. Based on the analysis of agro-climatic characteristics and relief morphometric characteristics, optimal conditions were selected and cultivation of citrus cultures – on landscape basis (GIS analysis).

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