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Scientific Heritage of Professor Nikoloz Beruchashvili (1947-2006)

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Abstract: A special issue "New Challenge for Geography: Landscape Dimensions of Sustainable Development" (journal; "Earth Sciences") is dedicated to the 70th birthday anniversary of Prof. Nikoloz (Niko) Beruchashvili – a famous Georgian geographer and cartographer, PhD in Geography at the Chair of Department of Cartography and Geoinformatics of Tbilisi State University, head of the scientific-research LAB studying the states of environment with aerospace methods (1979-2006) and Physical-Geographical Station of Martkopi (1982-2006), the Chair of the International Geographical Union's Commission on Landscape Analysis (2004-2006). This issue discusses modern problems of landscape science and related fields of knowledge. In the 1970s, N. Beruchashvili organized and managed a program of annual observations on the dynamics of landscapes at Martkopi physical-geographical center and also seasonal observation centers for different landscapes of Georgia. He also organized expeditions to the Caucasus and different parts of the World. He established air observations of the landscape conditions to study its dynamics. On the basis of these observations, he developed a spatial-temporal concept of landscapes. He introduced some terms to landscape science (such are geomasses, geohorizons, vertical structure, stexes - daily conditions, etc.) and developed main principles. He published more than 220 scientific works, 28 of them are monographs (Tbilisi, Paris, Moscow).As a researcher, N. Beruchashvili visited and worked in 60 countries of the World. In 1975-1976, he did a special course at Paris VII University in France. In 1987-2005, he was invited to give lectures and did scientific works at different Universities (Warsaw, Sofia, University in Brno, Toulouse, Grenoble, etc.).He contributed to the introduction and development of the GIS-technologies in geographical researches in Georgia, as well as establishment of Chair of Geoinformatics at Tbilisi State University, Georgia. For the total period of his working at the Tbilisi State University, he organized a number of international forums. His students and scientific followers are working in different branches of geography and cartography, and they also work successfully in tourism, land cadaster, statistics, military analysis, urban planning, etc. The Special issue is prepared by Alexander Javakhishvili Geographical Society of Georgia.

Keywords: Landscape Studies, NTCs, Nikoloz Beruchashvili

1. Introduction

"Geography gradually acquires a new social function implying not only explaining the ongoing events, but also controlling, forecasting and, most important, managing the natural environment".

Niko Beruchashvili

In recent years, the landscape-ecological studies have become particularly important in the scientific-geographical works. In this connection, a great contribution was done by a

Georgian geographer, cartographer and scientific traveler, Professor Nikoloz (Niko) Beruchashvili (Figure 1). He left a significant scientific heritage, which still supports the development of the landscape science not only in Georgia, but elsewhere in the world. He is the author of a theoretical concept of spatial-time analysis and synthesis in the landscape studies, which is introduced to the curricula of a number of Universities.

In 1982-2006 Niko Beruchashvili headed the Chair of Cartography and Geoinformatics of Tbilisi State University (Figure 2), Georgia. During this period he contributed to education of brought up many young explorers. At the same time, he headed the Laboratory of Studies of the State of Environment with Aerospace Methods (1979-2006), was the Head of the Physical-Geographical Station of Martkopi Chair of the Commission on Landscape Analysis, International Geographical Union (2004-2006). In 2001 he founded "The Geographical Journal of Georgia" and was its Editor- in-Chief until his death (2006).

Niko Beruchashvili was the founder and first Chair of the Commission of Landscape Analysis of the International Geographical Union (IGU) (2004-2006). For years, he headed the National Committee of the Georgian Geographers (1994-2006) and was a Vice-President of the Geographical Society of Georgia (1998-2006). Niko Beruchashvili delivered lectures at Tbilisi, Paris, Toulouse, Grenoble, Warsaw, Sofia, Brno, Berlin, Rio-de-Janeiro, Moscow, Kiev and other Universities.

Figure 1. *Nikoloz (Niko) Beruchashvili.*

He was twice awarded the Order of Honor, 2000, 2003. In 1995-2000 he was a Soros Professor.

N. Beruchashvili published 220 scientific works, including 28 monographs and text-books. 25 Candidate of Science and 3 Doctor of Science dissertation theses were defended prepared under his suvervision. Among the postgraduate students of Prof. Beruchashvili there are the citizens of ten different countries.

The article presents great contribution of Professor Niko Beruchashvili to the development of landscape science and, in general, to geography in Georgia and in the world. The article examines main essence of the landscape study methodology developed by N. Beruchashvili and the results obtained based on these methods.

Figure 2. *Nikoloz Beruchashvili at Tbilisi State University.*

2. Main Results

2.1. Landscape Approach Methodology Developed by N. Beruchashvili

The conception of spatial-temporal analysis and synthesis of NTC was elaborated in 1980s at Tbilisi State University (Martkopi Physical-Geographical Station, Laboratory of Studies of the State of Environment with Aerospace Methods under guidance of Prof. Beruchashvili. Since then many theoretical and practical scientific works have been carried out and they all are based on stationary, semi-stationary, field and remote research methods. The main value of the methodology is that having based on unified methods it enables investigation of natural components, state of NTCs, peculiarities of structure and functionality, current state of landscapes and degree of anthropogenic transformation; elaborating spatial-temporal forecasting models for NTCs, etc.

Landscape-geophysical features are of special significance among the characteristics of natural-territorial complexes. N. Beruchashvili has made a special contribution to the processing and development of the methods to study these characteristics. Landscape Geophysics is a discipline of landscape studies, which involves general physical properties of natural-territorial complexes, the processes and phenomena occurring in them (e.g. the issues of substance circulation and transformation). It means that the field of study of Landscape Geophysics combines all general processes and phenomena taking place in natural-territorial complexes [1]. Therefore, it is quite correct that the French Scientific School called it a Discipline of the Physical and Biological Principles of the Environment Dynamics, and D. Armand called it the Study of the Physical Interrelations of Landscape Components. Besides, the sphere of Landscape Geophysics involves the study of the issues of industrial influence on landscapes. This issue is considered as a

geophysical factor by Landscape Geophysics [2; 3].

On the basis of the method of N. Beruchashvili the scientific analysis of NTCs and their components requires studying of all structural units (e.g., geo-horizon) formed during the process of synthesis of elementary structural-functional parts – geo-masses in space and time and determining the regularities of interactionstaking place in landscapes. It is important to identify and determine the mutual influence of different characteristics combined in the field of study of Landscape disciplines (Geomorphology, Climatology, Soil Science, Phytocenology, Ecology, etc.). These characteristics are presented as the species of the vegetation cover, acidity of the soil (pH), humus type [1], also timber supplies, yield class of a forest, population quantity and density, industrial objects, etc. It is necessary to determine the anthropogenic meaning and transformation degree of landscapes according to demographic indicators.

The geo-masses of NTCs can be sorted in two classes according to horizontal and vertical distributions [4]. Landscape Geophysics pays special attention to the study of resource geo-masses (phyto-masses, zoo-masses, fine-particle soil, humus, total and productive damp, hydro-masses and etc.) that is the most effective means of assessment and protection of natural resources. Such approach is one of the important sides of this concept [1; 5; 6]. Exactly these factors increase the significance of the use of Landscape Geophysics (rational nature management, agricultural and environmental monitoring, etc). The landscape-geophysical approach also enables investigating dynamic characteristics in natural-territorial complexes, which is very essential for environmental monitoring and forecasting.

Initially, term landscape structure only meant its "spatial structure" and "landscape morphology" [7]. Later, it also involved the horizontal and vertical aspects of its spatial formation. Nowadays, landscape structure also comprises time structure [8]. Therefore, many authors [9; 10; 11] distinguish three types of landscape structures:

Horizontal (morphological) structure;

Vertical structure;

Time structure.

Landscape Ethology is a new trend in Landscape Studies. It enables determining the tendencies taking place in natural-territorial complexes according to elementary parts (geo-masses), vertical structure and functionality. Its basic practical meaning is that it forms a theoretical base for the spatial-temporal analysis of landscapes and physical-geographical regions. The base is supposed to transmit the information on average long-standing and potential states of natural-territorial complexes and above all, it has a great significance in elaborating the environment management systems [12].

N. Beruchashvili contributed a lot to the development of landscape ethology and its novel approaches. Landscape Ethology is a new trend in Landscape Studies. It enables determining the tendencies taking place in natural-territorial complexes according to elementary parts (geo-masses), vertical structure and functionality. Its basic practical meaning is that it forms a theoretical base for the spatial-temporal analysis of landscapes and physical-geographical regions. The base is supposed to transmit the information on average long-standing and potential states of natural-territorial complexes and above all, it has a great significance in elaborating the environment management systems [12].

During the recent period the landscape-ecological researches have become very actual. Their main task is to reveal stable, sensitive and critical areas of landscapes, their current states and the transformation degree of the territory. All the above mentioned is very important for solving numerous tasks of rational nature management and landscape planning. N. Beruchashvili tried to develop a method to identify the critical landscape areas. First, this was done in one administrative unit of Georgia (Borjomi Municipality), and later, all over the country [13].

2.2. Field Landscape Studies

Based on the concept of spatial-time analysis and synthesis of the natural-territorial complexes, almost all the territory of Georgia is studied. On the initiative of N. Beruchashvili, many expeditions were organized both in Georgia and beyond its borders. He visited 60 countries of the world with scientific purposes, among them Brazil, Bulgaria, United Kingdom, Germany, Egypt, Spain, Italy, Russia, France, Ukraine, Switzerland, Czechia, Chile, etc. He predominantly studied the landscapes of the mountainous areas (Figure 3). He headed the world expeditions with participation of his colleagues, disciples and students.

Numerous researches have been carried out in the field of Landscape studies under the guidance of Prof. N. Beruchashvili (Figure 4). These researches are based on the analysis of landscape-geophysical and landscape-ethologic parameters conducted on the basis of field, stationary and semi-stationary observations in Caucasus and other regions of the world, e.g. in the north-west of the European part of the former Soviet Union [14], the central European part of the former Soviet Union [15], Carpathians [16; 17; 18], the Crimea [19; 20], West Kopet Dag [21; 22], south-west Bulgaria [23], the north-east Caucasus [24], the forest landscapes of the temperate zone of north America [25] and etc.

The methods of field landscape studies, besides the description of physical-geographical objects, implies office and laboratory work. Such analysis allows identification of the amount of geo-masses (aerial masses, zoo-masses, litho-masses, mortmasses, pedomasses, phytomasses, hydro-masses), description of the vertical structure of the natural-territorial complexes and identification of the peculiarities of horizontal and vertical distribution of geo-masses, with a particular accent on phyto-masses.

The expeditions yielded a bulk of field materials – the plots of landscape descriptions and field maps. Some of these materials are published, but most of them are preserved at N. Beruchashvili's family archives. As the studies held in the Caucasus suggest, the total number of the field plots is about

1000, including approximately 600 plots for Georgia. These studies were accomplished in all regions of Georgia (Figure 5). 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.

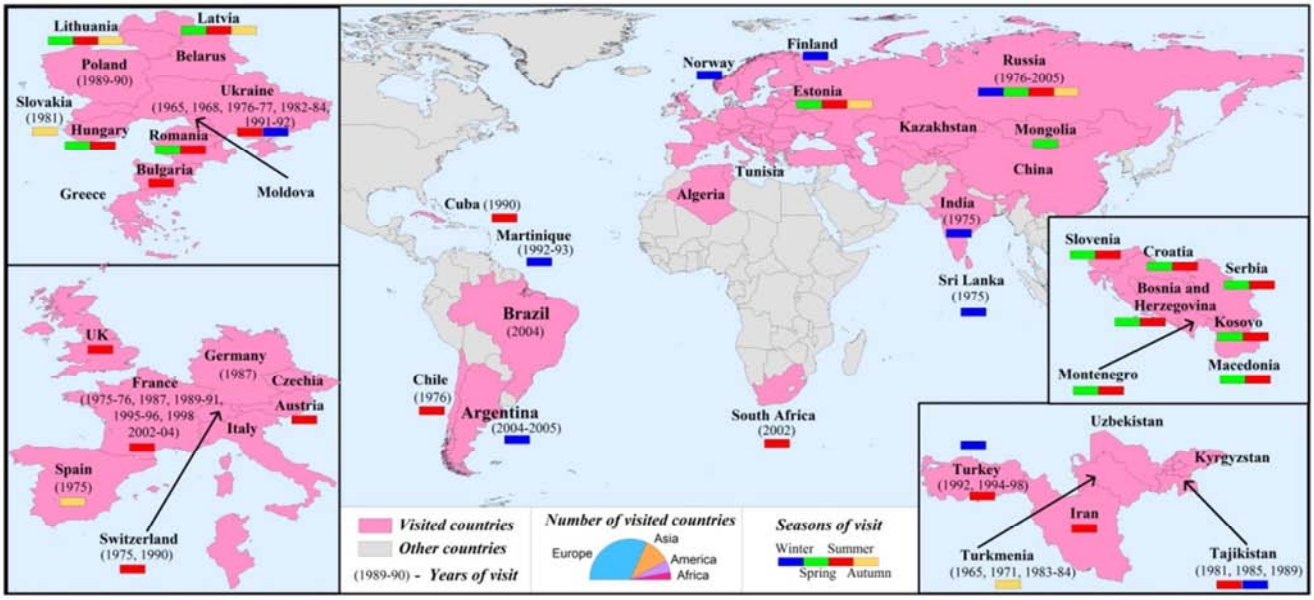

Figure 3. *Visited countries by N. Beruchashvili.*

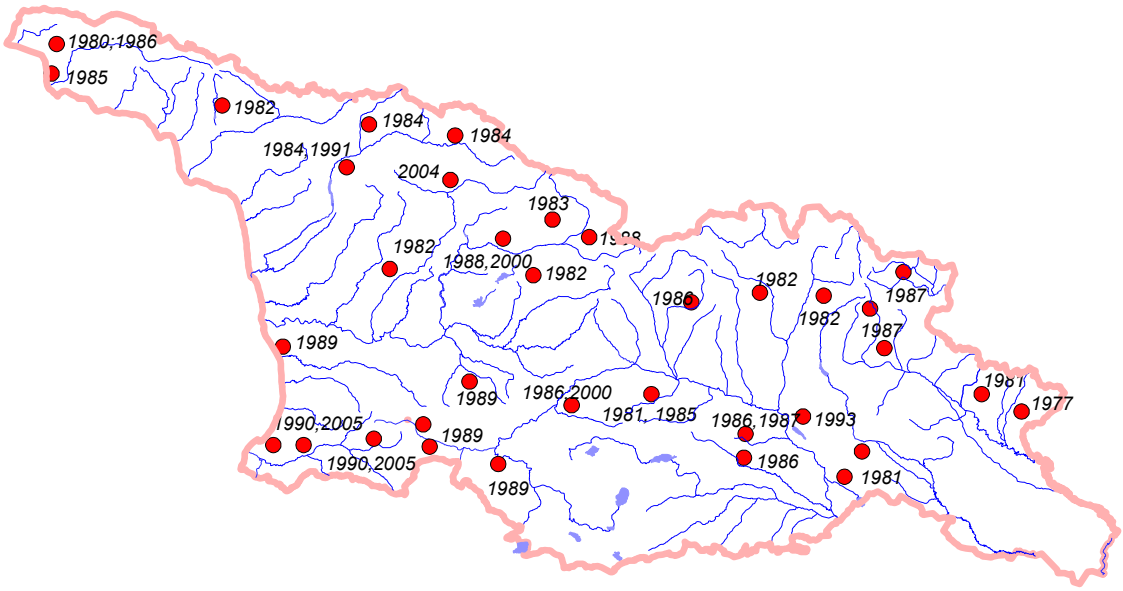

Figure 4. *Field works in different regions of Georgia carried out under the guidance of Prof. N. Beruchashvili.*

Results of field works were reflected in many publications. Some parts of these works describe theoretical issues of Landscape Geophysics and Landscape Ethology [6; 9; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36]. There are publications of collections of scientific works on numerous issues of landscape geophysics [37; 38; 39]. On the basis of spatial-temporal analysis and synthesis conception these scientific works describe study of the states of natural-territorial complexes, issues of cartography, separate methodological approaches. These researches are based on the analysis of landscape-geophysical and landscape-ethologic parameters conducted on the basis of field, stationary and semi-stationary observations.

The analysis of the degree of the landscape-geophysical and landscape-ethological study demonstrated that mountain landscapes are studied better than plane landscapes. The situation is absolutely opposite in the field of physical-geographical study. Such state of affairs has several reasons:

Most of the stations needed for the physical-geographical analysis of the territory are located on plains and in piedmont areas, while they cover only 11% of field expedition plots.

The only physical-geographical station of Georgia is located on a plain. It is true that the results of the explorations accomplished regularly in the environs of the

station can be generalized and applied to most of the landscapes of east Georgia, but this is not sufficient, particularly for the detailed large-scale studies.

The methods of the landscape-geophysical study of the natural-territorial complexes are more oriented on the studies of mountainous areas and are approved for this purpose.

Figure 5. *Nikoloz Beruchashvili during the field work.*

As for the mountainous landscapes of Georgia, they too, are studied at different degrees. Some landscapes, such as middle-mountains forest landscapes of the Caucasus with beech forest domination [40], were a part of some concrete studies considering some of the landscape-physical and landscape-geophysical properties, as well as issues of anthropogenic transformation of the territory and other questions. The upper-mountain forest landscapes of the Caucasioni are also explored [41]. The present paper gives the physical-geographical factors forming the mentioned landscapes and quite a thorough analysis of the major landscape-geophysical properties. A particular accent is made on soil-surface formations, in particular, their definition, structure, classification and distribution. As for other landscapes of Georgia, virtually they have never been a subject of concrete studies. However, the natural-agrarian territorial complexes of Georgia and their conditions nevertheless got covered by studies [42].

The analysis of the degree of exploration of the landscapes of Georgia demonstrated that the high-mountainous landscapes are least studied. This is true not only with subnival or nival, but also with subalpine and alpine meadows. However, there are individual works [43] considering some questions of landscape geophysics. We think that low degree of exploration of these landscapes must be resulted from the fact that the studies mainly accented forest natural-territorial complexes (while the greatest forest areas in Georgia are found in the mountains). This is evidenced by the bulk experimental plots, too – 87% of the total number of such plots are for forest natural-territorial complexes.

In respect of degree of exploration, 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 (Table 1).

Table 1. *Distribution of Experimental Plots in Region of Georgia.*

Regions of Georgia	Number of field plots	%
Racha-Lechkhumi - Kvemo Svaneti	96	17.4
Shida (Inner) kartli	91	16.5
Kvemo (lower) Kartli	74	13.4
Abkhazeti	60	10.9
Kakheti	54	9.8
Samegrelo- Zemo Svaneti	46	8.4
Imereti	32	5.8
Eastern Georgian Mountain Region	31	5.6
Samtskhe-Javakheti	30	5.4
Adjara	29	5.3
Guria	8	1.5
Total	551	100

2.3. N. Beruchashvili's Role in the Development of Station and Semi-Station Landscape Studies

In 1961, a commission aiming at studying the environs in the village of Martkopi and identifying the possibility of locating a training station there, was established at TSU. The station must have served the field practical trainings of the Faculties of Geography and Biology of TSU. On the commission's decision, a location in the southern piedmont of Saguramo-Ialno Ridge, on the left side of the river Tevaliskhevi (the right tributary of Aliskhevi), 1 km north-west of village Martkopi, was selected. The major criteria for selecting the station meeting the students' requirements for practical trainings, were as follows:

(1) Short distance from Tbilisi making it easy for the professors, lecturers and students to travel to and fro any time of the year;
(2) Close location of different landscapes swiftly giving the students a view about the major landscapes of east Georgia (piedmont steppes, low-mountain oak forest, oak-and-hornbeam forest, middle-mountain beech forest, upper-mountain secondary subalpine forest), as well as the close location of the agricultural plots of field allowing the students observing the degree of anthropogenic transformation of the territory. This was also quite important because across these landscapes, the main branches of agriculture of piedmonts of east Georgia are presented;
(3) Presence of the white cliff formed as a result of backward erosion at the mouth of the river Aliskhevi, on the southern slope of Saguramo-Ialno Ridge allowing the students observing these processes;
(4) Presence of drinking water what is another important fact to organize long (lasting for several days) students' training.
(5) The location chosen for the station is in the steppe landscape of the piedmont hills dominating in the piedmont of east Georgia and adjacent areas.

So, the existing surroundings were very important to organize complex student's field training and scientific studies. The first head of Martkopi station was M.

Saneblidze, and N. Beruchashvili was one of his favorite students and a successor of his job. N. Beruchashvili took upon himself the management of Martkopi station. "In the years 1971-1976, Dr. Beruchashvili organized and led a program of year-round observations on the dynamics of landscape at the Martkophi Station. Stationary studies of such intensity - unknown before to the international research community have enabled scientists to quantify diurnal states of landscape that Dr. Beruchashvili called stexes. On the basis of the station's research data, Dr. Beruchashvili has developed the concept of landscape geophysics whose principal notions are geomasses and geohorizons" [44].

N. Beruchashvili laid a foundation to the semi-station landscape observations in Georgia. There operated quite a vast network of semi-stations covering different landscapes of the country, from the plane and hilly landscapes through high-mountain landscapes. These semi-stations are: Miusera, Lagodekhi, Bakuriani, Bevreti and Vashlovani stations.

One of the most powerful semi-stations was found near Martkopi station, on Ialno Ridge and in its piedmont. The observations here were accomplished on 5 experimental plots [6]:

(1) Over the slope of a northern exposition with beech forests, at 1750 m asl, in the environs of mountain Nakokhari;
(2) On the crest with subalpine meadows, at 1770 m asl, in the environs of mountain Nakokhari;
(3) Over the slope of a southern exposition, with subalpine meadows, at 1700 m asl, in the environs of Tsivtskaroskhevi;
(4) Over the slope of a southern exposition, with beech forests, at 1640 m asl, in the Tsivtskaro basin;
(5) On the Erosive-denudation White Cliff circus, at 1500 m asl.

Weather-booths were placed here, and regular decade observations of the following parameters were accomplished:

(1) Total solar radiation and albedo in the vertical section of the natural-territorial complexes;
(2) Radiation and thermal balance in the vertical section of the natural-territorial complexes;
(3) Micro-climatic observations;
(4) Identification of the quantities of fractional particles of phyto-masses in the aboveground and partly, underground parts of the natural-territorial complexes;
(5) Study of the soil fauna (partially).

The weather-booths operated on Kovaluki plateau, in Lagodekhi Reserve, in Kazbegi, Bakuriani, Bevreti and Vashlovani. At present, the observations are suspended.

The territory of Ialno semi-station is extremely diversified in respect of its landscape. There are 29 landscapes, the facies, identified in this small area (Figure 6).

Thus, the study demonstrated that the territory of Martkopi station is distinguished for high landscape diversity. The comparison of this area to the other upper-mountain and high-mountain landscapes of east Georgia showed that the landscapes presented on the territory of the semi-station presents almost all typical natural-territorial complexes spread in east Georgia within the limits of 1600-2400 m asl. Consequently, the results of the mentioned studies can be applied to most of the upper-mountain and high-mountain subalpine landscapes of east Georgia.

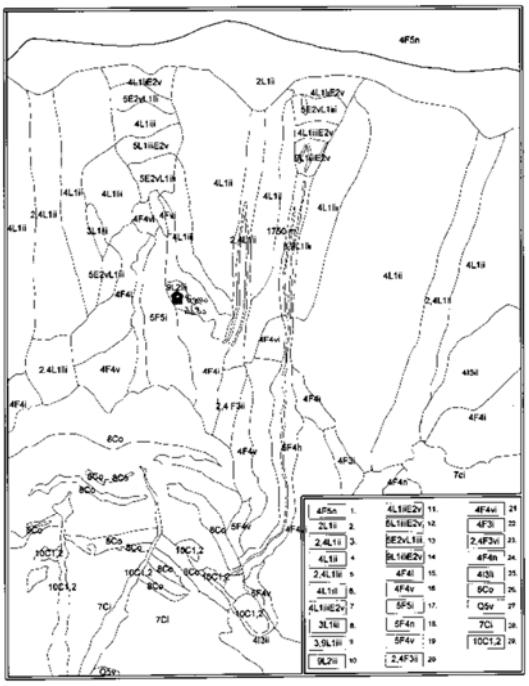

Figure 6. *Landscape map (types of NTCs) of Ialno semi-station (author: N. Beruchashvili).*

Landscape facies: 1. Slopes of a northern exposition with average inclination, with trans-elluvial regimen and dead-covered beech forest; 2. Crests with an autonomous regimen, with leguminous-gramineous-herb meadows; 3. Inclined Crests of a southern exposition, with transelluvial regimen, with leguminous-gramineous-herb meadows; 4. Slopes of a southern exposition, with average inclination, with transelluvial regimen, with leguminous-gramineous-herb meadows; 5. Inclined slopes of a southern exposition, with transelluvial regimen and herb meadows; 6. Averagely inclined slopes of a southern exposition, with transelluvial regimen and herb meadows; 7. Averagely inclined slopes of a southern exposition, with transelluvial regimen, with herb meadows and bushes; 8. Inclined slopes of a southern exposition, with herb meadows; 9. Hollows, with herb meadow; 10. Inclined slopes with alluvial accumulative regimen, with Subalpine tall herbaceous cover; 11. Averagely inclined slopes of a southern exposition, with transelluvial regimen, with leguminous-gramineous-herb meadows and bushes; 12. Steep slopes with transelluvial regimen, with herb meadows and subalpine bushes; 13. Steep slopes with transelluvial regimen, with bushes and herb meadows; 14. Inclined slopes with elluvial-accumulative regimen, with herb meadows and bushes; 15. Averagely inclined slopes of a southern exposition, with transelluvial regimen, with beech forests and gramineous herb cover; 16. Averagely inclined slopes of a southern exposition, with transelluvial regimen, with beech forests and bushes; 17. Steep slopes of a southern

exposition, with beech and hornbeam forests, with gramineous herb cover; 18. Steep slopes with transelluvial regimen, with dead-covered beech forests; 19. Steep slopes of a southern exposition with transelluvial regimen, with beech forests and bushes; 20. Inclined slopes and crests with beech forests and gramineous herb cover; 21. Averagely inclined slopes, with beech and hornbeam forests, with gramineous herb cover and bushes; 22. Averagely inclined slopes of a southern exposition, with hornbeam forests and gramineous herb cover; 23. Inclined autonomous slopes and crests with hornbeam forests, bushes and gramineous herb cover; 24. Averagely inclined slopes, with sparse dead-covered beech forests; 25. Averagely inclined slopes of a southern exposition, with transelluvial regimen, with oak forests (Quercus macranthera); 26. Cliffs with plant aggregations and agglomerations; 27. Semi-humid forest macro-structures with deciduous shrubs; 28. Slopes with transelluvial regimen, with plant semi-associations, meadows and bushes; 29. Elluvial-accumulative surfaces, with vegetation aggregations, agglomerations, meadows and bushes.

2.4. Landscape Studies in Georgia Based on the Concept of Spatial-Time Analysis and Synthesis of Natural-Territorial Complexes

A number of scientific works have been written based on the concept of spatial-time analysis and synthesis of natural-territorial complexes developed by N. Beruchashvili. These works concern different issues of landscape studies.

The environs of Martkopi station and Ialno Ridge are studied best of all with numerous published papers dedicated to this problem [45; 46; 47; 48; 49; 50; 51; etc.]. Most of the papers are based on the data of two research stations (Martkopi station, or "Lower Base" and Ialno Ridge, 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 questions of solar energy transformation in Martkopi environs are discussed in the work by T. Jibladze [52]. The work considers the issue of the solar energy distribution in different periods of the year and for different morphological units of landscapes. The questions of studying and modeling the climatic processes taking place with the landscapes of the Caucasus are considered in the work by M. Elizbarashvili [53]. Based on standard weather data analysis, the works evaluate the climatic-resource potential of the landscapes by using quantitative methods and develop the plan and criteria of their transformation (presented as the values of air temperature and atmospheric precipitations), reaction of local climates to the global changes (warming, desertification, air temperature abnormalities). As for the high-mountain subnival and nival-glacial landscapes, the climatic regime of landscapes is modeled for them.

Based on the analysis of outcomes of the semi-station physical-geographical observations, the environs of Amtkeli Lake and Kovaluki Plateau were studied [54; 55; 56]. These studies mainly focus on the questions of seasonal dynamics of the NTCs. The study of the environs of Kovakuli Plateau [56] is based on the semi-station observations of the Kolkhish humid subtropical (piedmont hilly) landscapes held in 1981-1989. In addition to the landscape-geophysical and landscape-ethological analysis, the concepts of semi-station of Kovaluki Plateau for 10 parameters of NTCs are given. As for the study of Amtkeli Lake environs [57], it is mainly the geophysical analysis of these environs – the plane, lower-mountain and middle-mountain landscapes. The questions of structure and dynamics of the NTCs, associations between the individual geo-masses and index of biological cycle are studied.

The geophysical analysis of the landscapes of the Lesser Caucasioni to identify the system of protected areas and degree of diversity of the landscapes is considered in the work by N. Jamaspishvili [58]. This work is an attempt to identify the favorable sites for the ecological corridors and protected areas by using a landscape-based approach.

The questions of dynamics of the vertical structures of the NTCs of the Caucasus are studied quite well. Some works consider it during the summer stex of phytogenic structure stabilization [59], while other works consider it on the background of an annual cycle [60]. The questions of the daily states of the underground part of the NTCs are considered in the work by R. Maglakelidze [61]. The work thoroughly considers the principal peculiarities of pedo-stexes, the daily state of the soil and questions of identifying the boundaries of a stex layer, vertical structure of the underground part of NTCs and bio-geocycle.

The landscape-ethological situations and scenarios of the mountainous areas of Georgia are considered in the work by T. Gordeziani [62]. Svaneti and Dzama Gorge are selected as a model for the territory of Georgia. The major goal of this work was to develop the theoretical bases for mapping the TNCs. A particular accent is made on the questions of cartographic forms of synthesis, abstracting and generalization of the maps of these states in time.

Out of landscape-geophysical indices, phyto-masses are studied best of all. Some of the works dedicated to this problem give an analysis of phyto-masses of the landscapes not of some concrete areas, but of whole Caucasus or Georgia [63; 64; 65; 66; 67].

The issues of territorial planning of Georgia are highlighted in the work by N. Elizbarashvili [68; 69; 70]. The work develops the methodological bases of ecologically-oriented territorial planning of mountain landscapes, and large-, average- and small-scale landscape-environmental analyses of the mountainous territories of Georgia are done for the purpose of geo-ecological inventory and identification of social-economic functions of the landscapes.

As for the landscape-environmental studies, their number is smaller. However, some questions of landscapes are considered in the above-listed works, as well. In 2000-2005, under the guidance of N. Beruchashvili, there were quite thorough and diversified studies accomplished in different regions of Georgia within the scope of the forest sector

development project (WB). The principal value of these studies is the development of the methodology to develop the landscape-ecological frame first realized in Oni region. Based on this methodology, similar studies were accomplished for almost all forest regions of Georgia. The summary map of all these studies is so called "semaphore map" evaluating the stability of the landscapes to an anthropogenic impact (mainly, forest felling). It is this map giving the information about the sensitive and stable areas of the landscapes what is directly associated with the questions of the forest use.

2.5. Founder of Geo-Information Mapping in Georgia

The enormous scientific information requires systematizing and most of all, practical using, which in their turn need modern technologies, namely GIS. The use of technologies is many-sided as far as it includes statistical analysis of data, scientific researches, planning, design and etc.

At first, use of GIS technologies in geographical studies was limited to data systematization and serial, automatized compilation and edition. It is noteworthy that 20-25 years ago in Georgia certain scientific researches in this trend including Landscape Studies were carried out. Different types of thematic maps drawn at that time can be considered as just an "embryo" of geo-information systems. However, unlike many other countries, using of GIS technologies in Georgia actually begun by studying the daily state dynamics of natural-territorial complexes [8; 71].

The idea of Implementation of geo-information systems in Georgia belongs to Nikoloz Berouchashvili. At the Chair of Cartography-Geodesy of Tbilisi State University in 1980s different thematic digital maps were drawn using softwares NEOCHRON, DEGRAS, GRAPHIC ARTIST. For consequent show (display-films) of the maps HEOSHOW and ANIMATIC softwares were used [72; 73]. E.g. display-films of the dynamics of separate regions and landscape stexes of Georgia were compiled. The use of GIS in researches in Georgia actually began in 1991. At that time in Georgia there was functioning a single organization (Laboratory of Studies of the State of Environment with Aerospace Methods) at Tbilisi State University, where, using GIS MapInfo, different geographic data were processed, thematic maps of different scale were drawn and GIS-analyses were conducted [74].

2.6. Principal Works by N. Beruchashvili

N. Beruchashvili wrote over 200 works, including monographs and articles published in the local or international top-rated reviewed journals. His works incorporate about thirty monographs and text-books for the higher educational institutions. These works, besides Georgia, were published in France, Russia, Germany, USA, Italy, Great Britain. N. Beruchashvili's contribution to the development of the school geography is great. He developed the first novel text-book in the field of physical and social-economic geography of Georgia. in the "References" there are listed some works published in cooperation with N. Beruchashvili.

Niko Beruchashvili, as an expert of the Caucasus nature and landscapes and a researcher, who traveled to almost all corners of the Caucasus, created his works based on the analysis of the results of expedition, station, semi-station, hydrometeorological offices and other scientific sources.

The landscapes of the Caucasus, including those of Georgia are considered as one general unit and in great details in one of his monographs "Caucasus: Landscapes, Models, Experiments" [71], giving the landscape-geophysical and landscape-ethological characteristics at the level of the landscape sub-types, certain landscape "groups" or dominant types of the vertical structure of natural-territorial complexes. The monograph allots minor attention to geo-masses or different landscape-geophysical characteristics and analysis of the interconnections between the physical-geographical factors.

The greatest value of the work is that it shows the author's computer experiment of the climate change and its impact on the landscapes of the Caucasus. Thus, the geographical information-heuristic model of the landscapes of the Caucasus designed by using the geo-information and experimental systems allows identifying the response of the landscapes of the Caucasus to some or other physical-geographical conditions, e.g. if the average air temperature rises or falls by 2ºC, the annual amount of atmospheric precipitations will rise or fall twice and the territory of the region will forestate or deforestate.

The computer experiments were accomplished based on the data of 1977-1990 and revealed the structural-functional changes taking place in the landscapes, and modeling of the extreme conditions and natural disasters was also done.

The computer experiments yielded some very interesting theoretical outcomes, in particular:

(1) It was established that a short-term (1-day-long) increase in air temperature in the Pre-Caucasus has the same effect as the same air temperature rise for approximately 3 weeks in Kolkheti;
(2) Minor changes "equalization" effect associated with the self-restoration ability of the landscapes was identified;
(3) Critical limit "effect" was identified, which, if exceeded, leads to the demolition of a landscape structure;
(4) A cumulative effect of factors was identified meaning that the joint effect of such factors, which are insignificantly deviated from mean values, but may have the same effect as the one occurring in case of a significant deviation of one factor;
(5) Compensation effect typical to large areas and seen on the background of a parameter increase/decrease in one region at the expense of the same parameter decrease/increase in another region was identified; etc.

Geopolitical Atlas of the Caucasus (authors: N. Beruchashvili, Zh. Radvani) was published three times in the

French (Figure 7) and Georgian languages (1996; 1998; 2011) [75]. Several tens of historical, economic, ethnic, physical-geographical and geopolitical maps were compiled based on various statistical data and included in the Atlas.

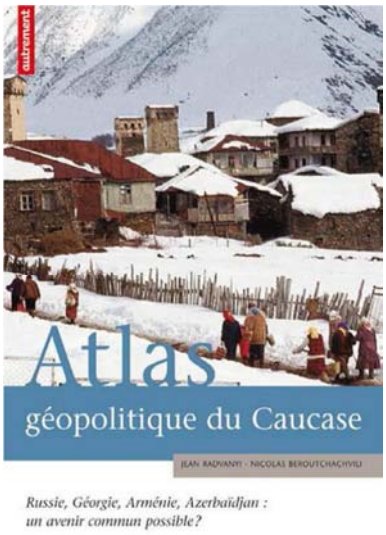

Figure 7. *Cover page of Geopolitical Atlas of the Caucasus.*

The main goal of the authors of the Atlas was to show the political, economic and social peculiarities of the Caucasus. The importance of the Atlas can be viewed in the historical and modern contexts. The Caucasus, rich in natural resources and located on the boundary between Europe and Asia, has always been a focus of numerous invaders since the ancient times. The recent strategic importance of the region has been resulted from the oil and gas basins discovered lately in the Caspian Sea basin making the region one of the hotspots of the world.

In 1991, a book by N. Beruchashvili and G. Rougerie "The Geo-systems and Landscape" [36] was published in Paris. The book gives a thorough description of the leading world landscape schools and their major achievements.

In 2000, they started to develop a draft of the United Nations Environmental Program (UNEP) – "Caucasus Environmental Outlook". The main goal of the project was to compile a regional report in the city of Johannesburg, at 2002 UNO World Summit. The scientists, experts and representatives of the leading organizations of all four countries (Georgia, Azerbaijan, Armenia and Russia) participated in the project. The general project coordination was the function of the UN Preliminary Prognosis and Evaluation Regional Office (DEWA) and Regional Office of Europe (ROE). The entity responsible for drafting the report was GRID-Tbilisi, and the work on the project took place at its office. The report was drafted under the general leadership of N. Beruchashvili and it was published twice in the English and Russian languages [76]. The work includes the analysis of 30-year-long data (1972-2002) of four countries concerning the social-economic indices, natural resources (land, forest, climatic, water, biological), environmental pollution and protection and natural disasters. The report had to describe the existing situation in the region and changes during the period since Stockholm Conference.

From 2005, Matrkopi station participated in the project of the International Geographical Union (IGU) "Geographical perspectives on sustainable development: Networking local area partnerships with teachers and young scientists". The major goal of the project was to develop the program of the questions related to the geographical aspects of sustainable development for students and teachers and compile teaching materials for them. There were 9 such centers in the world, with Martkopi station as one of them.

2.7. On the International Arena

In the 1970s', N. Beruchashvili worked on probation first and then, worked at different universities and scientific centers in France. Whilst in France, he walked around and carried out field observations in the Alps, Pyrenees, Massif Central and on the island of Corsica. He published several articles about mass, energy and composition of components of the landscapes jointly with his French colleagues.

N. Beruchashvili actively worked on the international arena. He headed several international projects. On the initiative of N. Beruchashvili, international scientific school "Interstex" was founded, bringing together the representatives of the universities and scientific schools from many countries. The principal goal of the school was to study, map and model the landscapes of the mountainous regions.

For years, N. Beruchashvili actively cooperated with the International Geographical Union and popularized the scientific work of Georgian geographers. N. Beruchashvili's authority at the International Geographical Union was so high that in 2004, the Commission of Landscape Analysis of the International Geographical Union was founded on his initiative, with N. Beruchashvili as its first chairperson. In 2002, on the initiative of this Commission, he organized an international conference, which was dedicated to the 150th Anniversary of the Georgian Geographical Society. Famous scientists from many countries of the world participated in the conference (Figure 8).

Figure 8. *At one of the working meetings of International conference, dedicated to the 150th Anniversary of the Georgian Geographical Society, 2002.*

From left: Salva Jaoshvil (Prof.), Arnold Gegechkori (Prof.), Nikoloz Beruchashvili, Nikita Glazovski (Corresponding Members of RAS), Anne Buttimer (President of IGU in 2000-2004), Pierre Thorez (Prof., emeritus)

Since the 1980s, N. Beruchashvili headed the intercollegiate students' field landscape expeditions with the participation of the students and graduates from France, Germany, Bulgaria, Russia, Ukraine, Estonia, Cuba and other countries.

To date, the representatives of the landscape school established by N. Beruchashvili and his students continue to work at different scientific centers and universities.

3. Conclusions

The works by N. Beruchashvili had major influence on the development of landscape science and generally of geography, in Georgia and also in the world.

Through his studies, N. Beruchashvili:

(1) Developed the methodological issues of the landscape science (concept of spatial-time analysis and synthesis of NTCs, the principles of landscape classification, landscape geophysics and landscape ethology etc.);

(2) Identified the landscape-geophysical and landscape-ethological peculiarities of the of Georgia and Caucasus and made the Landscape map of Georgia and Caucasus;

(3) Developed a series of thematic maps of Georgia in different issues of landscape-geophysics and landscape ethology.

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