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ANTHROPOGENIC TRANSFORMATION OF LANDSCAPES OF EASTERN GEORGIA AND THE CURRENT ECOLOGICAL SITUATION

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Abstract. The landscapes of eastern Georgia (Caucasus) are increasingly exposed to anthropogenic impacts and are replaced by natural-anthropogenic or completely transformed landscapes. These processes can be observed worldwide, though with different intensity. The underlying causes include the construction of hydro energy facilities, uncontrollable (illegal) felling of trees, pasture overload, and so on, which inevitably have a serious impact on the environment and cause frequent and increasingly intensive geodynamic processes such as erosions, landslides and mudflows. These processes are facilitated by steep slopes composed of less steady Jurassic shale, sandstone and partly by cretaceous sediments and heavy precipitation (1 600 - 1 800 mm/year in north-eastern part, Lagodekhi). The study of the impacts of particular anthropogenic factors on Eastern Georgian landscapes made it possible to design a model of the region – a landscape-ecological map showing ecological factors characteristic of a particular landscape zone and highlighting ecologically hazardous areas.

Key Words: Landscape, anthropogenic transformation, ecological situation, geodynamic processes, Eastern Georgia, Caucasus.

I. INTRODUCTION

Anthropogenic impacts on the environment, the intensity of environmental processes and changes in the landscape structure are among important issues of modern geographical studies. Among the numerous works devoted to these problems, we could mention those of Milkov, who, together with his alumni, studied anthropogenic landscapes of Russia from theoretical as well as practical perspective (1973, 1974, 1978). The role of anthropogenic factors in the development and transformation of complex landscape is also dwelt upon in Rjabchikov's (1972), Solntsev's (1977) and Isachenko's (1974) works.

An ample methodological coverage of issues relating to the anthropogenic landscapes of Georgia (Caucasus), their classification and the study of the close connection between natural and social factors in terms of landscape formation are available in Davit Ukleba's work "Anthropogenic Landscapes of Georgia" (1983). Landscape transformation and the systemic nature and utilization of landscapes of various genetic levels are also discussed in Beruchashvili's (1995, 2000) and Elizbarashvili's (2000, 2005) publications, while individual components of Georgian landscapes and the significant changes caused by anthropogenic interference are studied in the prolific works by Ketskhoveli, who focused on vegetation (1935, 1960) and monographs by Sabashvili (1965), Davit Chkhikvishvili (1953) and Nakaidze (1977), whose main target was ground cover changes (collapses).

As concerns the ecological study of Georgian landscapes, its methodological basis is the spatio-temporal analysis and synthesis of natural and natural-anthropogenic landscapes developed by Beruchashvili (1995). The methodology was designed for the study of mountainous landscapes. Landscape-ecological research principles and methods were developed by Ukleba (2001), who foregrounded the ecological approach consisting in the study of all aspects of human-nature relations as well as the systemic approach – the analysis of interrelationship between natural components and interdependence of natural processes.

The current situation of landscapes is clearly reflected in the area-specific transformations, that is the correlation and spatial organization of natural or modified landscapes (Elizbarashvili, 2005,).

In 1993, Salukvadze (1993) developed a landscape-ecological map of the Tbilisi-Rustavi suburban area, which was the first attempt to visualize the ecological situation of landscapes in Georgia.

In the wake of the above-mentioned research, the present article highlights the current ecological state of eastern Georgian landscapes resulting from past and ongoing natural and anthropogenic transformations.

II. STUDY AREA

Eastern Georgia is situated in the central part of the South Caucasus, in the borderline zone between Asia and Europe, in a subtropical belt, between the northern latitudes 41^0 and 42^0 46' and eastern longitudes 44^0 29' and 46^0 44' (fig. 1). The eastern Georgian territory mostly lies south to the main watershed of the Caucasus, while a small part of it passes over the northern slope. The country area is basically mountainous, with distinct vertical zones of natural resources.

Apart from highlands, there are plains as well, where, unlike highlands, landscapes or their individual elements are subject to a different type of transformation, with different intensity and pace.

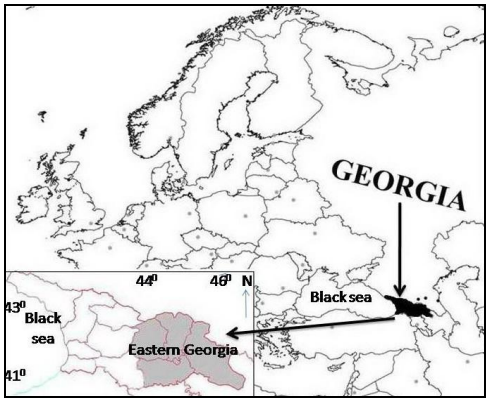

Fig. **1** Location of the study area

Eastern Georgia is among the most extensive and densely populated areas of Georgia (especially, the lowlands). Its historico-geographical areas are Shida (inner) Kartli, Kvemo (lower) Kartli, Kakheti, Mtiuleti, Tusheti, Pshavi and Khevsureti. The most important cities in the area are Tbilisi (the capital of Georgia), Rustavi, an important industrial city, also Gori, Telavi, Kaspi, where the development of respective economic sectors is closely linked with natural conditions and resources typical of eastern Georgia.

61% of the territory is highlands and 39% lowlands. The greater part of eastern Georgia is occupied by mountainous forests and alpine valleys. The lowlands consist of a succession of small uplands and a pit) and is covered by steppes, shrubs, meadows and mostly by anthropogenic landscapes.

The article focuses on three experimental areas of eastern Georgia: the Tbilisi pit, the Alazani plain and the eastern Caucasus (Kakheti Caucasus).

The geographical position of the eastern Georgian region, its complicated relief and climatic conditions determine its extraordinary natural diversity and have a strong impact on the landscape variation, structure and dynamics. Here are arid (the Iori upland) and mild humid subtropical plains (the Alazani Plain), also moderately warm humid mountainous, high-mountainous subnival and nival landscapes (the Caucasus of Kakheti, Tusheti). However, mountain and plain landscapes on the territory of eastern Georgia have developed under different conditions and vary in terms of modification rate and duration.

The natural transformation of landscapes take hundreds and thousands of years, while the anthropogenic interference, i.e. human economic activities can change the natural landscape in a very short time (several dozens of years). The landscapes of eastern Georgia are increasingly exposed to anthropogenic impacts. The considerable changes in nature are caused by the construction of hydro energy facilities, unsystemic (illegal) felling of trees, pasture overload, and so on, which

are certain to have a serious impact on the environment and cause frequent and increasingly intensive geodynamic processes: erosions, landslides, mudflows. Besides, the region falls within an active seismic zone.

The majority of eastern Georgian landscapes have been altered. The natural boundary of forest landscapes in the near past reached 2300-2500 m from the sea level (Gogichaishvili, 1988), but at present under the anthropogenic impact it does not exceed 1900-2000 m, very rarely 2100-2200 m (Kvachakidze, 1996). In the Kakheti Caucasus oak forest landscapes are irregularly distributed. In the central and western parts are rather vast areas of oak forests because of the drier climate. In many places, irrational human activities (felling, pasturing, fires) caused degradation of oak landscapes and sometimes they are substituted by oriental hornbeams (*Carpinus*), and xerophilous and steppe landscapes. Hornbeam landscapes cover especially vast areas on the slopes of eastern and western exposition. Pure hornbeam landscapes are of secondary origin and they developed in the place of main forest landscapes – oak (*Quercus*) and beech (*Fagus*) forests under the anthropogenic impact (felling). Beech landscapes (1500-1800 m from the sea level) can be found in the Pankisi, Stori and other gorges. In some places they appear as rare relict plant groups (laurel groove) and mixed deciduous forest.

Out of mountain forest landscapes of eastern Georgia (Kakheti), middle mountain landscapes are less altered. They have relatively preserved their main appearance as compared to piedmonts, low mountain forests and high mountain valley landscapes. This has been determined by complex orographic conditions of mid-forest landscapes unfavorable for habitation and hence for the economic activity. Piedmont and low mountain forest landscapes were felled and converted to secondary meadows and agricultural lands. Less populated high-mountain landscapes are intensively used as pastures. Middle mountain landscape utilization began later, after low and high-mountain landscapes (Salukvadze, 2006). Thus they suffered less anthropogenic changes and have better preserved their primary appearance. Under the influence of human economic activity in the upper part of forest landscapes, the percentage of anthropogenic vegetation (meadows and shrubs) is considerably high.

The piedmont area and plains are more transformed than their adjacent mountain areas. The piedmont slopes adjacent to the Alazani plain are subject to intensive erosion, denudation and landslide debris cone formation that play a part in landscape transformation. 88% (1.912 km^2) out of the total area (2.177 km^2) of the Alazani Plain is occupied by anthropogenic landscapes and only 12% (264 km^2) by natural landscapes.

Mountains cover more than 70% of the total area of eastern Georgia. Many settlements are located 1.000 meters above the sea level. The slopes steeper than 10° occupy 70%, 36% of which are steeper than 20° (Machavariani, 1988). The division is sometimes 2-3 km and more, and the depth of dissection is up to 3.000 m. Large areas in the mountainous regions are above 2.000-3.000 m. The high slopes, heavily dissected terrain, heavy rains and human interference determine the intensity of erosion. In the mountains, the most common water erosion occurs primarily as a result of improper plowing, grazing and logging.

An average of 60-70 tons/ha of fertile humus layer is annually washed away from croplands in eastern Georgia (Machavariani, 1988). In mountains, 100-300 tons of soil cover is washed every year. They are annually resulting in tens of thousands of hectares of land transforming into a less intense land, but part of the land is completely removed from the economic turnover. Debris flows, which are among the main types of modern geodynamic processes, are common in central and eastern parts of the Caucasus and the Trialeti Range (Table 1).

Table. 1 The number of mudflow areas in eastern Georgia (included in the mudflow cadastre)

Basin	**The number of mentioned mudflows**	
	Basins	**Flows**
Tergi(Terek)	36	41
Kura	277	642
Liaxvi	39	40
Lexura	5	5
Ksani	17	18
Aragvi	49	49
Iori	74	125
Alazani(night side area)	27	50
Alazani(left side area)	71	188
Tushetis Alazani	61	96
Total	**656**	**1254**

Source: Tsereteli E., Tsereteli D., Geological Conditions of Mudlow Development in Georgia, Tbilisi, Metsniereba Publishers, 1985, 11.

Mudflows are more typical of the eastern part of the Caucasus, the Kakheti region, due to continental climate, accumulation of weathering products and improper gazing. Disastrous mudflows are especially characteristic of inner Kakheti. They spur instantaneous denudations and accumulation of torrents, entailing destruction of economic facilities and losses. Mudflows are particularly common in Stori, Lopota, Duruji and Chelti river gorges.

The Duruji river basin poses enormous danger. The town of Kvareli (Kakheti region, eastern Georgia), situated in the middle reaches of the river, has been repeatedly destroyed by Duruji mudflows, suffering enormous losses and even human deaths. The total mass amounted to 50 million m^3 and more than 150 million m^3 at particularly hazardous sites. From 1.888 to 2.000, 25 large and 5 disastrous (in 1949, 1963 and 1975) mudflows took place in the area. More than 200 people died and enormous damage was inflicted on Kvareli region and the town itself (Bondyrev et al., 2007).

In eastern Georgia, at the fallout of 30-50 mm/day precipitation, there are favorable circumstances for the formation of hard constituents of mud streams. This type of mudflows is characteristic of declivities bordering with the cities of Tbilisi, Telavi, the town of Sighnaghi, etc.

In the modification of landscapes landslides play an important role, which are prevalent in eastern Georgia but they appear particularly intense on the southern slopes of the Greater Caucasus (Table 2).

Table 2 The number of landslide areas on eastern Georgian urban territories (included in the landslide cadastre)

Regions of landslide	**The number**
Shida (inner) Kartli	470
Kvemo(lover)Kartli	84
Mtiuleti	973
Kakheti	613
Tbilisi	60
Total	**2 200**

Source: Bondirev, I.V., Tavartkiladze, A., Tsereteli E.D. *et al*., Geography of Disasters and Risk, Tbilisi, Poligraph Publishers, 2007, 69.

Landslides classically are identified in the north-eastern slopes of the Gombori. In terms of its geological structure, recent tectonics, adolescence of mountain relief and intensity of development of modern geodynamic processes, the Gombori Ridge is a unique model not only for eastern Georgia, but for the Caucasus as a whole.

Landslides are characterized by quite non-homogeneous conditions of development, kinematics, mechanisms of displacing, depth of bedding and generations. These processes inflict enormous damage on the economy of Kakheti region – thousands of ha of arable lands are withdrawn from agricultural turnover, sylvan massifs and historical centers of Kakheti, including the town of Sighnaghi, is in the high- risk zone.

Rock falls, which cause changes in environmental conditions, are situated in canyons of Aragvi, Liakhvi, Ksani, on the northern slopes of the

Greater Caucasus. Extensive damage to vegetation in eastern Georgia is caused by anthropogenic (technogenic) effects, particularly in the lowlands, where anthropogenic vegetation prevails over forest vegetation. The subalpine and alpine meadows too are affected by pasture digression.

III. MATERIALS AND METHODS

The research is based on a compex physical-geographic, field study, benchmark mapping, semi-stationary observation methods and GIS analysis. To establish landscape situations and their dynamic, remote materials (air and space photos) of various years were deciphered in order to provide qualitative analysis of natural objects and processes within a reasonable time.

The research draws on textual and cartographic resources (topographical maps of Tbilisi pit, Kvemo Kartli, Kakheti region 1: 100.000, 1: 50.000, designed in 1972 and updated in 1982 by the Russian Military Headquarters).

We used also the 1884 Plan of Tbilisi (scale 1:10.500), 1976-1984 topographic maps and Google (2007 and 2006-2010 field survey data). Specific areas were subject to permanent control against maps by means of the Garmin Etrex Handheld GPS.

IV. RESULTS AND DISSCUSSIONS

A landscape model of the region was developed based on the effects of certain anthropogenic factors on the landscape. It is a landscape-ecological map showing the main types of landscapes together with certain environmental factors (Atmospheric air, surface water and soil contamination, mudflovs, landslides), and indicating areas of ecological stress. The degree of ecological pressure of on a landscape zone was determined through a mixed quantitative and qualitative analysis of main natural and anthropogenic factors. For instance: soil erosion was determined by the intensity of soil washing – less than 5 t/ha at weak erosion and 50 t/ha and more at strong erosion.Taking into account the overrun of the maximum permissible concentration of atmospheric air and surface water pollutants, landscapes with a high pollution index (>30 MPC) fall within the strong ecological strain category.

Ecological stress was revealed in landscapes where multisectoral industrial-territorial complexes are formed – these are landscapes adjacent to Tbilisi and Rustavi cities with developed industry and agriculture. More than 70% of expelled hazardous substances (dust, carbon dioxide, nitrogen oxides and other admixtures) are generated by manufactures situated in this zone, while the main

pollutants are motor-vehicles. The mentioned landscapes fall within the zone of strong ecological stress and ecological hotspot not only locally (i.e. in the research area) but at the national level.

According to the materials of the Hydro Meteorological Institute of the Technical University of Georgia (2013) and the Statistical Department of Georgia (2009), and also according to some authors (Svanidze, Ogbaidze, 2003; Ogbaidze, 2005,), main atmospheric air pollutants in Tbilisi and Rustavi are dust, carbon monoxide, nitrogen dioxide and plumbum. Plumbum concentration in the Tbilisi air basin 23.7 times exceeds MPC (0.1 mg/m^3).The main sources of air pollution in areas adjacent to Rustavi are the Rustavi metallurgical, building materials and cement plants (50.000 tons of cement dust emissions are produced annually). The dust is spread in a 20 km radius by north-western winds (the Annual Journal of the Statistical Department of Georgia). In Tbilisi, traffic accounts for 70-90% of the pollution (CO, NO_2 and Pb).

Main river pollutants are nitrogen and phosphorus, whose concentration determines the degree of surface water pollution. Non-organic nitrogen compounds (ammonium, nitrate and nitrite concentrations) have an increasing trend downstream the Mtkvari river. Ammonium concentration 1.5 times exceeds the MPC (0.39 mg/l), while nitrate (MPC 10 mg/l) and nitrite (MPC 1.0 mg/l) concentration is 3.4 times higher than the norm. Nitrate concentration in the Suramula river exceeds MPC 20 times due to sewage and agricultural discharges .

The most contaminated rivers are Mtkvari, Mashavera, Vere, Dighmula and Gldanisxevi (Table 3.).

Table 3. Some hydrochemical properties of small Tbilisi Rivers (2013)

Rivers	NO_2^- mg/l	NO_3^- mg	NH_4^+
Vere	0.4	4.2	20.2
Digmula	0.6	5.2	14.0
Gldaniskhevi	0.3	5.0	4.2
MPC mg/l	3.3	4.5	1.5

Source: Tabatadze, M., Dvalishvili N., Evalution of the Eco-Chemical Status of Main Tributaries of River Mtkvari in the City Tbilisi, Tbilisi, 241-245 pp., 2013. (in Georgian)

Heavy metals (copper, zinc) are the prevailing pollutants in Mashavera, Mtkvari and Xrami waters (Table 4). The Mashavera river is strongly polluted by drained water from the tailing dump of the neighboring Madneuli mining and processing complex of the Barytes and Polymetal Deposit (Khechikashvili, 2005). Copper composition in Mashavera waters reaches 730 mg/l (MPC 1 mg/l) and zinc

composition 329 mg/l (MPC 1). The population uses the contaminated water for irrigation as well, thus causing soil pollution

Table 4 Contamination water of Rivers by Heady Metals

Rivers	Cu mg/l	Zn mg/l
Mtkvari	90	158
Xrami	225	170
Mashavera	730	329
MPC mg/l	1	1

Source: Mdivani, S., Assessment of Anthropogenic Loading on the River Mtkvari at the Territory of Georgia, 2013

In the areas with a very high or high landslide risk (Gombori ridge, the basins: Alazani, Stori, Lopota, Chelti, Duruji, Kabali, etc.), where disastrous mudflows recur every 3 or 5 years, the rock and mud mass may reach from 7 to 10 million m^3. These areas cover a territory with clay deposits and loose Tertiary masses of eastern Georgian middle mountain zones and foothills (Tatashidze et al., 2000).

The article presents a fragment of landscape-ecological map showing Eastern Caucasus, the Alazani plain and the neighboring piedmont area, where destructive processes such as landslides, mudflows, avalanches, rock fall and flood are especially frequent (Fig. 2). Along with natural factors (intense manifestation of geodynamic phenomena: floods, landslides and avalanches), anthropogenic factors also play an essential role in the creation of ecological stress in the region.

To high stress zones we assigned middle and low mountain forest landscapes in the basins: Alazani, Stori, Lopota, Chelti, Duruji, Kabali, etc. In this region mountain forest landscapes are subject to various changes, due to active mudflows and soil erosion.

To the zones of particular ecological stress belong alpine and subalpine landscapes in the upstreams of Alazani, Tusheti Alazani, Lopota and other rivers. Part of the landscapes are prone to deflation due to erratic pasturing. Therefore, there is a real need for setting and observing pasturing norms and terms. Another part (middle mountains and lowlands) is subject to water erosion and other processes (mudflows, landslides,). Weak ecological stress caused by irrigation erosion can be observed in the Alazani plain.

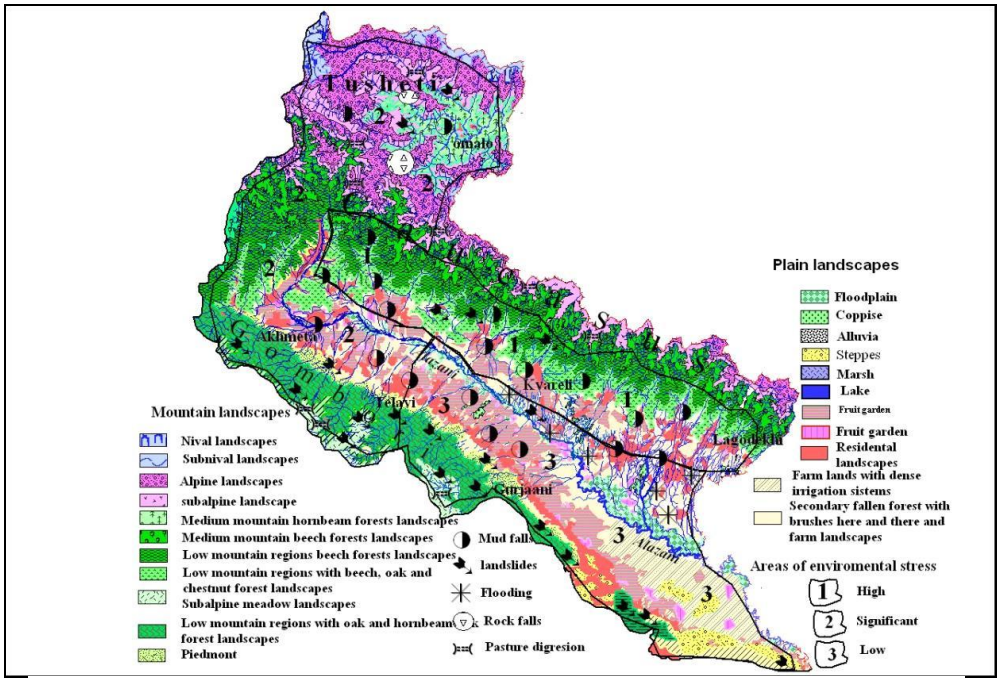

Fig. 2. Landscape-ecological map of eastern Georgia (fragment: Shida (inner) Kakheti, Tusheti).

Cities and urbanized areas of eastern Georgia are marked by an especially high degree of environmental transformation. 48% of Tbilisi and its surroundings are formed by mountains and foothills. Many settlements are located 1000 m above the sea level.

The natural environment of the city of Tbilisi has undergone patchy changes. The current condition and development trends of Tbilisi natural environment are directly connected with anthropogenesis. Natural landscapes have been partly preserved in the city suburbs and are represented by thorn-bush steppes and oriental hornbeam-and-oak, oak-and-hornbeam and hornbeam-and-beech forests. They are gradually being replaced by new anthropogenic landscapes represented by new roads and residential and industrial zones of the city. The built-up part of Tbilisi increased 200 times in the course of the 19^{th}-20^{th} centuries. According to the data prior to 2007, the city territory totaled 372 km^2, while presently, under the modified municipal decree, it is 504 km^2.

Within the newly set boundaries, the urban area is dominated by residential landscapes occupying 40-52% of the total territory.

Cartographic materials and aerial and space photos of 1884-1984-2007 show that in 1884 natural landscapes made up 50% of the entire city territory (36.84 km^2) and were mostly represented by riparian woodland (floodplain forests) oriental hornbeam-and-oak forests and thorn-bush steppes. According to the 1984 topographic map, natural landscapes constituted 12% of the whole territory (311.28 km^2), while anthropogenic landscapes equaled 63%. In 2007, due to the city expansion, which mostly involved inclusion into its territory of natural landscapes, the latter reached 21%, while anthropogenic landscapes totaled 65% (Salukvadze et al., 2007).

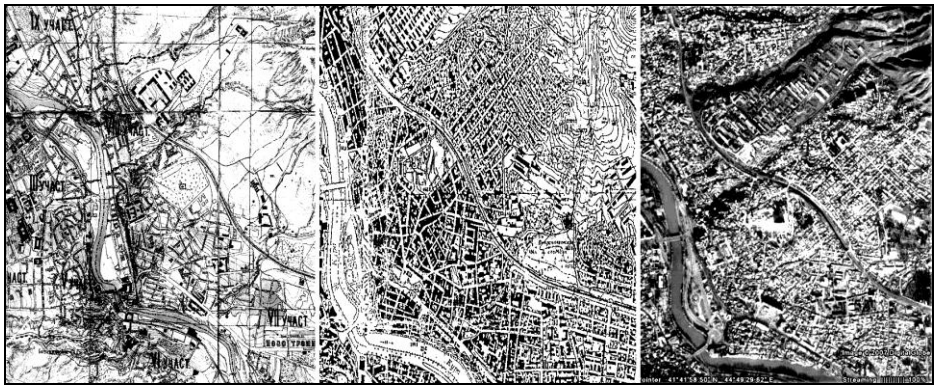

Fig. 3. The sources include: a map of Tbilisi (1884), topographic map 1984, a satellite Google image (2007) of the same territory

In some areas, technogenic factors (construction of houses, factories, factory, lines of communication and life support, etc.) caused the total alteration of the natural landscape. Pits and embankments developed as a result of open mining of quartz sand and drywall. Such activities lead to sharp depletion and degradation of ground. For example, in Ponichala, the southern part of the city, quarries are worked along the river Mtkvari, results in 2-4 meter wide pits that in turn bear a serious threat of intensive gully formation. These pits retain water and cause water logging. In some places, they are gradually covered by vegetation and develop into hygrophilous marshes. Natural processes are widely spread all over the city.

The combined impact of natural and anthropogenic factors not only leads to the violation and degradation (sometimes even complete elimination) of

vegetation, but also causes soil washing and the formation of swamps and ravines. As a result, considerable material damage is annually inflicted upon Tbilisi.

The spatio-temporal dynamic of the city landscapes has remarkably altered in the course of 100 years: natural landscapes decreased by 32%, natural-anthropogenic by 21%, while the total share of anthropized landscapes increased by 11% (fig. 4)**.**

In the majority of cases, the growth of transformed landscapes was caused by anthropogenic factors (uncontrollable (illegal) felling of forest, pasture overload). As a result of anthropogenic interference, every component and landscape of natural environment of Tbilisi and its suburbs was subject to various kinds of transformation.

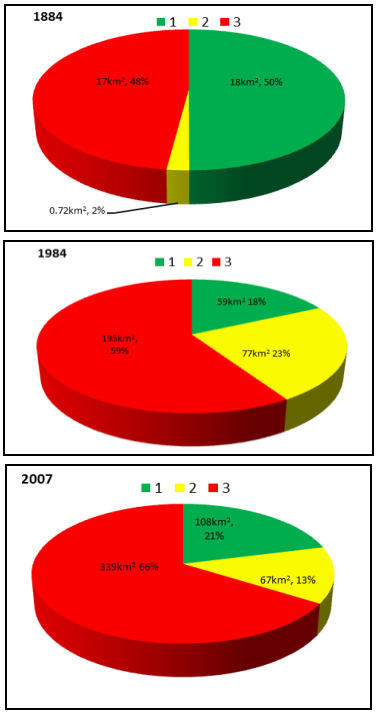

Fig. 4 The character of landscape transformation of Tbilisi in 1884, 1984, 2007. 1. Natural, 2. Natural-anthropogenic, 3. Anthropogenic

At an average precipitation intensity (0.2 - 0.5 mm /second) at the rate of 30-40 mm/day, all of gullies formed in the weathering crust of easily eroded tertiary rocks generate mud and debris flows that carry hundreds of thousands of cubic meters of rock and mud mass to the city territory. Over the past 40 years, 50 such cases were observed (Tsereteli et al., 1985). The precipitation rate of 30-50 mm / day creates favourable conditions for the formation of solid mudflows (Bondirev et al., 2007), which are typical of the slopes around Tbilisi. 60 landslides and over 20 km of damaged gravitational slopes were recorded on the territory of Tbilisi (Tatashidze et al., 2000).

Another hazardous environmental process observed in the region is flooding, which can be of natural as well as anthropogenic origin. It manifests itself mainly in areas with specific geomorphological and engineering-geological conditions.

The above-mentioned natural and anthropogenic factors inflict damage on agricultural lands cause destruction or partial degradation of residential and industrial assets, increase the seismic vulnerability of structural sites and deteriorate sanitary conditions among the population. There are 11 flash flood areas on the territory of Tbilisi. Recreational activities also have a significant impact on natural landscapes of Tbilisi, threatening the local biodiversity.

V. CONCLUSION

Landscapes as well as other dynamic open systems are classical homeostases capable of structure development and resumption even under significant but not long-term environmental changes, whether natural or anthropogenic. Landscape transformation in Eastern Georgia can be assessed as a complex process in which anthropogenic factors (deforestation, pasturing etc.) prevail. In fact, the greater part of the landscapes has been subject to significantly transformation.

The complex evaluation of eastern Georgian landscapes and the analysis of natural and anthropogenic factors active in the area facilitated the development of a landscape-ecologic map and the establishment of ecological stress zones.

Complex ecological circumstances were revealed in landscapes where multisectoral industrial-territorial complexes are formed - landscapes adjacent to Tbilisi and Rustavi cities with significant levels of industrial and agricultural development. Physical and chemical composition of underground waters is significantly altered under the influence of anthropogenic factors especially in urban areas and downstream.

To high stress zones were assigned middle and low mountain forest landscapes in the basins: Alazani, Stori, Lopota, Chelti, Duruji, Kabali, etc. In this region mountain forest landscapes are subject to various changes, due to active mudflows and soil erosion.

Cities and urbanized areas of eastern Georgia are marked by an especially high degree of environmental transformation. In 2007, due to the city expansion, which mostly involved inclusion of natural landscapes into its territory, the latter reached 21%, while anthropogenic landscapes totaled 65%. Within the newly set boundaries, the urban area is dominated by residential landscapes occupying 40-52% of the total territory. Thus, Tbilisi suburbs can be assessed as a critical ecoregion holding a significant place in the biodiversity of Georgia, as according to earlier research data (Berouchashvili, 2000; Bondirev et al., 2000,.) from 97 to over 100 landscape types were revealed on the Georgian territory (69,7 thousand sq.m.).

Moderately arid subtropical landscapes of Eastern Georgia, mostly concentrated in Tbilisi neighborhood, make up 28% of plains.

Thus, as a follow-up of the present research, we recommend the implementation of landscape-ecological examinations in all agglomeration areas of Tbilisi and develop a scientific vision of area development master plan in agreement with the city municipality. Besides, the research results can be used by national and regional regulators of environmental protection and natural resources for the elaboration of sustainable development measures. They can also be widely used for structural design, planning, etc. A landscape-ecological map of the environment can be successfully used to forecast natural developments against increasing anthropogenic factors.

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