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Tbilisi's climatic-landscape peculiarities and their dynamics

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Abstract

The current condition and development tendencies of natural environment of capital of Georgia - Tbilisi are directly connected with the anthropogenesis. Analyze of changing of environment peculiarities of rapid expansion of Tbilisi city and according to it revealing its landscape-climatic changes is the aim of the research paper. The diverse landscape of Tbilisi suburbs is represented by forests, forest-steppes, steppes, shrubs, *etc*. The variety can be attributed to complex relief's geological structure, diversity of climate, flora and fauna, and to the location between two different geostructural areas – the mountain system (Trialeti, Saguramo-Ialno) and intermountain valleys (Marneuli and Gardabani lowlands). Natural landscapes have been partly preserved in the city suburbs, but even they are gradually being replaced by new anthropogenic landscapes: new roads and residential and industrial zones. 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. Transformation of natural landscape of territory of Tbilisi into the anthropogenic one, has changed the physical condition of underlying surface. Especially, heat balance of the city was changed, which was followed by increase in air mean temperature (0.4-0.5°C) and precipitation and reduction of wind speed.

Key words

Climatic landscape, Transformation, Tbilisi

Introduction

In view of the landscape diversity, ecological, historical and cultural significance of the territory, it is important to fully realize and estimate all natural, aesthetic and historical-cultural merits of the region, in order to ensure their effective utilization.

To achieve this goal, it is necessary to trace the norms of spatial - temporal development of particular landscapes, Tbilisi natural components, and estimate the nature and degree of anthropogenic impact on the natural environment in question through a comprehensive analytical approach.

The 1884-2008 works aimed at the assessment of Tbilisi landscapes dynamic development and their anthropogenic transformation included landscape designation, identification of boundaries, observation of particular landscape components and their detailed study in sample sites (Salukvadze *et al.,* 2007).

Due to lasting economic activities triggering substantial changes, the primary natural landscapes of Tbilisi and its suburbs have been completely transformed and presently appear as anthropogenic landscapes. Natural landscapes have been partly preserved in the city suburbs and are represented by thorn-bush

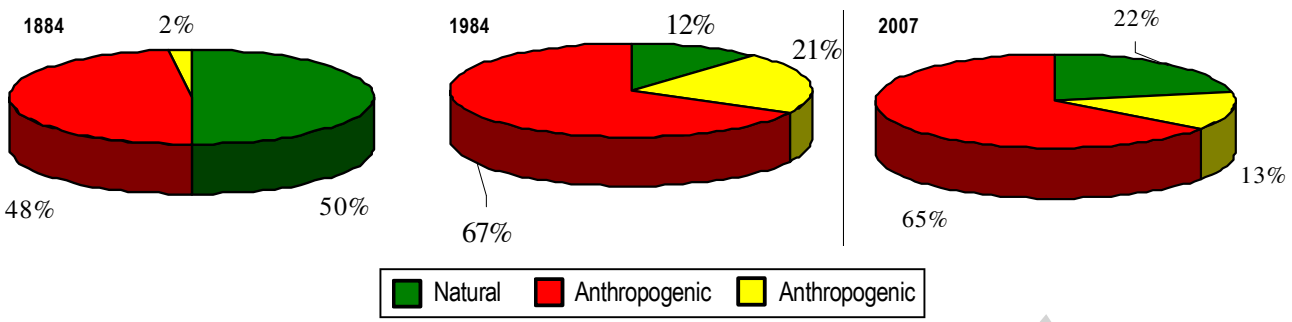

Fig. 1: Tbilisi's landscapes transformation dynamics (1884-1984-2007)

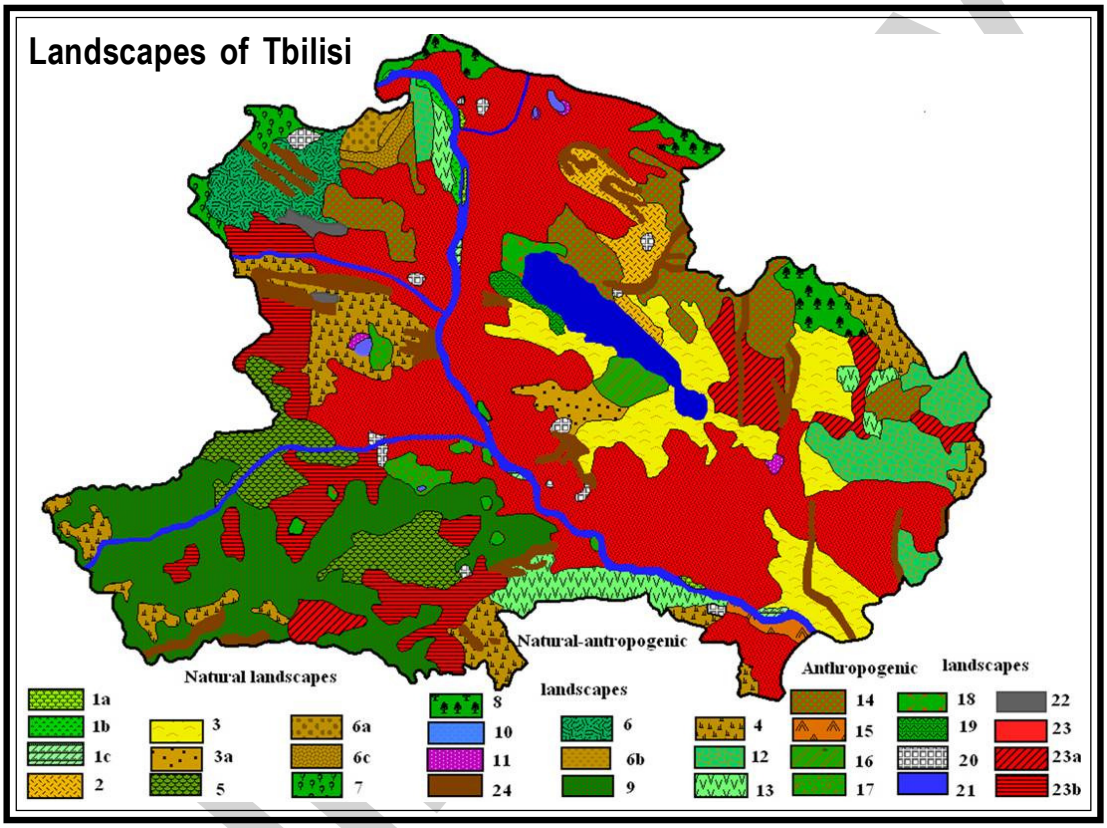

Fig. 2: Landscapes of Tbilisi: Total area - 504.58 km^2, including: (1a) Riparian woodland with an undergrowth shrub layer - 0.36 km^2, (1b) Bushes - 0.1 km^2; (1c) Herbaceous cover and light sandy soil - 0.08 km^2, (2) Thorny-bushes steppes - 3.24 km^2, (3) Steppes and halophilous landscapes - 39.02 km^2, (3a) Steppes - 3.24 km^2, (4) Thorny-bushes steppes with anthropogenic landscape - 28.72 km^2, (5) Oriental hornbeam and thorny bushes – 25.35 km^2, (6) Oriental hornbeam and oak forests, thorny-bushes, occasional artificial plantations – 12.18km^2, (6a) Steppes with anthropogenic landscapes - 2.56 km^2, (6b) Thorny-bushes on washed soil - 0.19 km^2, (6c) Thorny-bushes on brown soil - 3.03 km^2, (7) Oak-hornbeam-juniper landscapes - 4.2 km^2; (8) Oak and oriental hornbeam forests - 9.48 km^2, (9) Oak and hornbeam forests and secondary forest shrub with recreational infrastructure - 54.64 km^2, (10) Lakes - 0.8 km^2, (11) Wetlands - 0.85 km^2, (12) Vineyards – 16.63 km^2, (13) Fruit gardens - 10.3 km^2, (14) Vegetable gardens and arable lands - 25.14 km^2, (15) Natural deposits - 0.6 km^2, (16) Forest parks - 3.84 km^2, (17) Parks - 3.87 km^2, (18) Public gardens - 2.1 km^2, (19) Artificial forest zones - 2.05 km^2, (20) Cemeteries – 2.64 km^2, (21) Reservoir, the Tbilisi sea - 10.4 km^2, (22) Badlands - 1.21 km^2, (23) residential landscapes (urban) -164.48 km^2;, (23a) Residential landscapes (rural) - 26.97 km^2, (23b) Seasonal residential landscapes - 26.53 km^2, (24) Dry ravines and gullies - 15.74 km^2, (25) Mtkvari river bed - 4.04 km^2

steppes and oriental hornbeam-oak, oak-hornbeam and hornbeam-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 19th-20th 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.

Despite the above-mentioned, the Tbilisi territory has still retained landscape diversity, which can be attributed to the variety of local relief and microclimate. The aim of this study was to determine

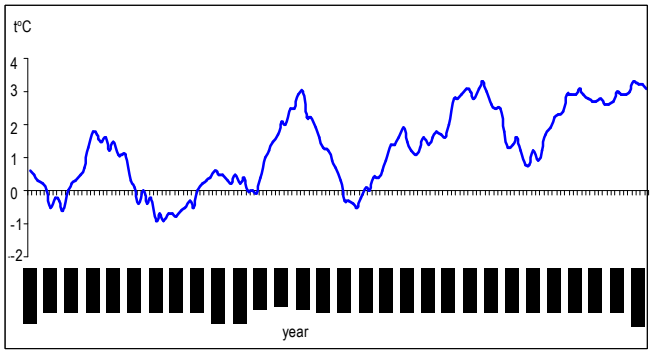

Fig. 3: Secular trend of temperature according to the running decades (Tbilisi, January)

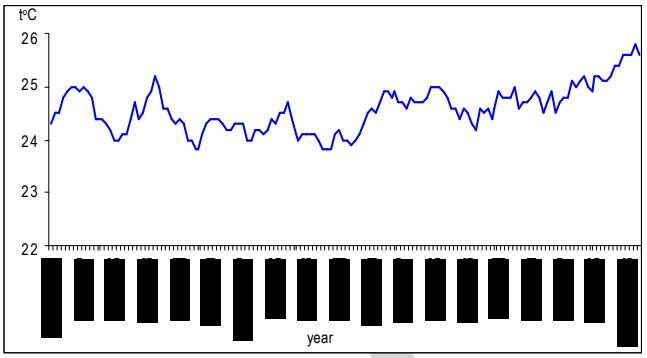

Fig. 4: Secular trend of temperature according to running decades (Tbilisi, July)

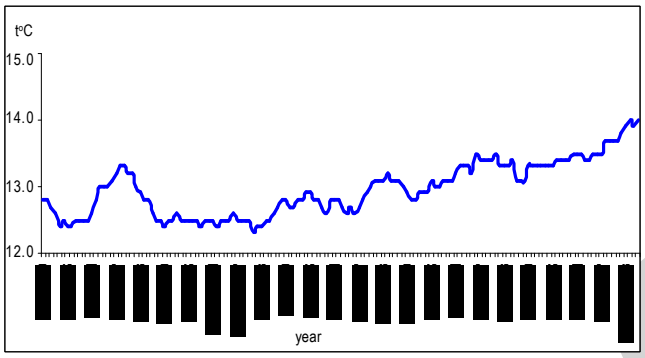

Fig. 5: Secular trend of temperature according to running decades (Tbilisi-yearly)

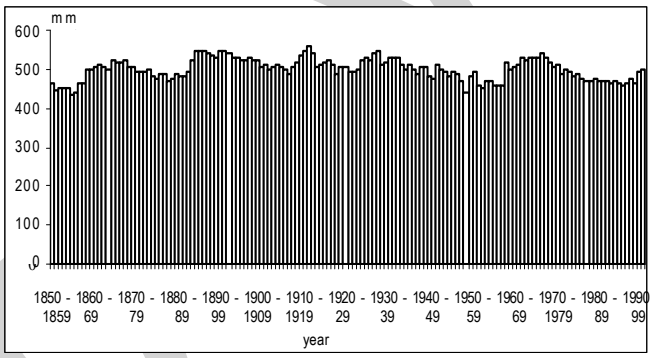

Fig. 6: Secular trend of precipitation according to the running decades (Tbilisi)

the landscape changes depending on climate change around Tbilisi, in Georgia.

Materials and Methods

The study was carried out all over Tbilisi. For comparison analysis and calculation of areas of different landscapes of Tbilisi following reference materials were used: 1884 year Plan (scale 1:10 500), 1976-1984 topographic maps, Goggles 2007 and 2006-2008 field survey data. Map of landscapes of Tbilisi was made by GIS system.

Dynamics of climate of Tbilisi was analyzed by secular trend (1850-2006) of air temperature and precipitation according to running decades.

Results and Discussion

Cartographic materials and aero- and space images of 1884-1984-2006 show that in 1884 natural landscapes made up to 50% of the entire city territory (36.84 km^2) and were mostly represented by riparian woodland (tugai), oriental hornbeam-oak forests and thorny-bushes steppes.

According to the topographic map of 1984 (Fig. 1), 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 the natural landscapes, the latter reached 24%, while anthropogenic landscapes totaled 37%.

The spatial-temporal dynamics of the city landscapes had remarkably altered in the course of 125 years: natural landscapes decreased by 38%, natural-anthropogenic ones – by 23%, while the total share of anthropized landscapes increased by 15%. In the majority of cases, the growth of transformed landscapes was caused by anthropogenic factors.

In the consequence of anthropogenesis, every component and landscape of natural environment of Tbilisi and its suburbs was subjected (Fig. 2) to various kinds of transformation, which has been clearly shown on the map of Tbilisi landscapes designed by means of GIS technology.

Therefore, Tbilisi suburbs can be appreciated as a critical ecoregion, holding an important place in the biodiversity of Georgia. The study (Bondyrev *et al.,* 2000) revealed that 97 different landscape types can be singled out on the territory of Georgia (total area being 69.7 000 km^2). According to other data (Beruchashvili, 2000) their number was over 100. Consequently, per every 10,000 km^2 the number of landscape type equals 1.4. Out of them, especially remarkable were the moderately dry subtropical landscapes of plains (28%), the greater part of which were found in Tbilisi suburbs and distinguished by a high degree

of diversity – 9.6 types per 100 (from the Azerbaijani border to Tbilisi), in Tbilisi-Gori-10.7 types per 100 km (Seperteladze *et al.,* 2000). Consequently, potential urban development of Tbilisi and its territorial expansion at the expense of natural landscapes may cause changes to the biodiversity of the critical ecoregion. Hence, it is very important to develop a scientific vision for the general territorial development based on a complex landscape study and comprehension.

Climate is one of the determining factors for landscape formation, that's why studying of secular trend of climate is essential. Many years running data of air temperature and precipitation characterizes the climate change. Especially reliable was a temperature row, because it was more stable and prolonged element. Precipitation is also very interesting element, but it is not so reliable for its fluctuation (Mumladze, 1991).

Tbilisi meteorological station has one of the long observation rows in Southern Caucasus and is a representative one. Systematic observation data on climate elements (air temperature and precipitation) for Tbilisi exists since 1844. Secular trend of these elements according to the running decades characterizes current changes of climate of Tbilisi. For this we analyzed coldest (January) and warmest (July) months and yearly air temperature curves.

Coldest month January's secular trend of temperature according to the running decades are characterized with cyclic recurrence. Four warm and four cold periods are well expressed in the Fig.3. Duration and amplitude of these periods varied with time. The first positive period, that is called anomaly warm period concerns to 60-70's of 19th century. Its norm is 0.7^{o}C and from norm deviation 0.8^{o}C. The second warm period began from 1906-1915 decades and lasted around 15 years. It was characterized with increase in temperature, which achieved its maximum value (3.0^{o}C) in 1915-24 decades. Mean deviation of this period was 1.0^{o}C. The third relatively long period begans from 1936-45. Deviation was approximately 1.3^{o}C. The 4th warmest period is especially interesting. It launches from 1971-1980 decade and lasts up today. Mean deviation of this period was 2.6^{o}C, which exceeds the norm by 1.4^{o}C. In this period the highest temperature (3.3^{o}C) was recorded in 1994-2003 decade. This decade was estimated as the warmest one in a global scale.

What is the reason of such warm January in Tbilisi during the last years? It is well known that in the large cities air temperature is higher than in its suburb, just the same situation is in Tbilisi, where in suburb parts air temperature is lower by 0.4^{0}C. That was natural to put a question - was enlarging of city a reason for increasing in air temperature? Of course it is, but main background of rising of temperature is a global warming, which was more expressed in winter time in the whole north hemisphere. "Urban" effect of the city that is expressed by joining the suburb, intensive rising of population (more than 1.2 mln) and buildings, complicated ecological situation (reloaded transport network) caused increase in air temperature by 1.2^{o}C during 100 years in Tbilisi, than in other geographical point of Georgia (Mumladze, 1975).

The warmest month's (July) secular trend of temperature according to the running decades did not show significant oscillation from many year norms (24.6^{o}C). Only last 2 decades showed (Fig. 4) increase in temperature around 1^{o}C.

In the period of investigation (160 years) of secular trend of yearly mean temperature of Tbilisi (Fig. 4) was characterized by well expressed increase in air temperature during 4 decades. Such rising can be explained by the domination of Eastern type circulation as it is shown in the Atmosphere Circulation Catalogue (Girs, 1960).

It is well known that air temperature does not affect as strong on the vegetation cover as precipitation (Fig 6), especially its low indices. As it is shown on the Fig 6, the secular trend of precipitation is not characterized by cyclic recurrence (mean many year norm is 499 mm). Analysis of secular trend of main elements of climate (air temperature, precipitation) showed that the climate of Tbilisi had not changed significantly. Recently, especially in the last 2 decades sharp increase in air temperature and slight increase in precipitation positively affected on the vegetation cover and was favorable for further development of the landscapes of Tbilisi.

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