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# DISCOVERING THE CONSEQUENCES OF GLOBAL CLIMATE CHANGE IN GEORGIA'S REGIONS, RESULTS AND ADAPTIVE MEASURES

**Dali Mikautadze, Tsitsino Davituliani, Ia Iashvili and Magda Kvabziridze**

*Akaki Tsereteli State University, Georgia*

In Georgia, a classical example of poly climatic country the problem of "people and climate" is very dramatic. Therefore in 1994, the country has ratified the Framework Convention on Climate Change, has been involved in the process of completing number of commitments, in 1999 and in 2009 introduced its I and II National Communications. In this research paper as study objects, two important regions of Georgia are chosen. Based on regional model of climate change PRECIS we have undertaken research that led to findings that in these regions climate volatility is observed. Based on the data of the last ten years temperature increase trend is obvious. Based on research results number of vulnerable sectors and regions were identified and measures to soften and adapt to the climate changes were formulated.

**Keywords:** Climate, Framework convention, Global warming, Vulnerable sectors, Clean development mechanism.

## Introduction

Among the challenges that humanity faces climate changes were recognized as serious problems at the first world conference dedicated to the climate change, held in 1979. In 1992, at the high level summit held in Rio de Janeiro Framework Convention on Climate Change was signed with the declared goal of "stabilizing concentration of greenhouse gases in the atmosphere to the levels clearly formulated several guidance principles, out of which especially important are "caution" and "joint but differentiated responsibilities of the parties" principles ("Second national", 2009, p.13) These principles place a leading role to overcome climate changes to the developed countries but also state that each country should contribute to the goal based on their abilities. Georgia shares these principles and has ratified the convention in 1994 ("First national", 1999) and has since actively engaged in the process of implementing principles of the Framework Convention and fulfilling country liabilities. In 1999 Georgia presented it's first, and in 2009 its second national communications. In these works number of vulnerable sectors and regions are identified. In both documents Georgia verifies that adaptation of climate change vulnerable systems and exposed sectors of the economy are priority for the country ("Second national", 2009, p.5)

Special attention is given to the Black Sea coastal zone which is considered tourism and economic development zone, as well as to the land degradation issues since historically Georgia has always been and agricultural country and agriculture is still considered as one of the most important sectors of the economy. Although share of Georgia in the global emission of greenhouse gases is less than 0.1% ("Second national", 2009) it is actively engaged in the process of reducing the emission and supports any

programs or projects that will reduce their emission from the territory of Georgia. It will bring additional clean investments in the country and will switch the economy to the sustainable development.

## From the Research History

Description of Georgia's climate have been found as early as in the works of antiquity philosophers --- Herodotus, Hippocrates (V c. BC), Strabo (I c. BC), etc. (Figurovski, 1912). Scientific research of climate was started only after organizing instrumental observation – since 1844 (Voeykov,1898; Figurovski, 1912). It is this period that publication of researches and monographs about climate of Georgia and its regions started (Kordzakhia, 1961; "*Climate"* 1971; Mumladze, 1991).

As noted above Georgia joined the Framework Convention on Climate Change in 1994 ("First national", 1999). The problem to be solved was to evaluate climate trends on the Georgian territory in XX century. Based on the scenario of anticipated climate changes to solve the formulated problem in the first approximation, three priority regions were selected in Georgia-Black Sea coastal zone, Dedoplistskaro region and Lower Svaneti, where in the periods of I and II communications theoretical researches were undertaken by Georgian research institutes and scientific authorities. At the same time Euro commission project aimed at increasing Clean Development Mechanism (CDM) potential was completed, which was intending to prepare foundations to implement CDM projects in South Caucasus and Moldova, joint project of United Nations Development Program (UNDP) and Global Environment Fund (GEF) (UNDP-GEF in numbers, 2012) to raise the quality of national inventarization of greenhouse gases ("Second national", 2009). Due to the difficult Geographical conditions Georgia is an example of poly- climatic country where the problem of "people and climate" stands very firmly. Therefore changes in the small territory like Georgia are more painful than in some other regions with larger territories where climatic variety is so small that they can be characterized as mono- climatic countries (Mumladze, 1991, p.3).

**Table 1.** Movement of average annual values of air temperature and precipitation sums in Georgia, 1955-2005.

| № | Meteo station | Average annual air temperature periods, in °C | | | Annual sum of precipitation | | Difference (II – I) | |
|---|---|---|---|---|---|---|---|---|
| | | I | II | II-I | I | II | mm | % |
| 1 | Poti | 14,4 | 14,6 | 0,2 | 1837 | 2078 | 241 | 13 |
| 2 | Kutaisi | 14,7 | 15,1 | 0,4 | 1412 | 1497 | 85 | 6 |
| 3 | Dedpolistskaro | 10,6 | 11,2 | 0,6 | 586 | 622 | 36 | 6 |
| | | | | | | | | |

Periods : I (1955-1970); II (1990-2005)
*Source:* Beritashvili, B., & Kapanadze, N., 2011.

Because of difficult natural conditions degree of climate change volatility is different in different regions of Georgia. Climate conditions of three regions discussed under UN Framework Convention on Climate Change fragmentally replicate the picture of climate change in the second half of the past century on Georgian territory. Obviously, we can not estimate full picture of climate change in Georgia based only on these data. Therefore we decided to study characteristics of climate dynamics of other regions, on the background of global warming, to make clearer the picture of country's climate conditions.

## Methodology and Research Findings

Georgia is situated in the south-eastern part of the Europe between Black and Caspian Seas. Its total area is 69.7 sq.km. Mountains cover most part of the country. 54% of the area is situated above 1000m from sea level. Mountain relief determines diversity of physical geography conditions of Georgia: its territory

covers humid subtropical lowlands and marshes, plains, uplands, semi-deserts, mountains covered by forests and glaciers, lakes and large number of rivers (Mumladze, 1991; "Second national", 2009).

We selected two important regions of Georgia for research- Poti and Kutaisi regions and studied characteristics of their climate changes. From the entire period discussed in the research paper (1905-2010) the period of second national communication was selected.

Poti is one of the most important points in Georgian Black Sea zone, it is one of the main seaports of Europe-Asia transport corridor (TRACECA) and an important land transport communication point. The city is crossed by one of the branches of river Rioni, "Rioni-Channel", which had initial water capacity of 700 $m^3$/sc. By 1998, due to the drift (sandbank) and increase of sea level, it was reduced to 300 $m^3$/sc. (Giginishvili, Metreveli, Gzirishvili, & Beritashvili, 1999). Data analysis show that average air temperature in the research regions changes 14,4-14,5°C and 16,6-15,8°C on the surface of the sea. Sum of precipitation varies between 1800-2000 mm. ("Second national", 2009; Beritashvili, & Kapanadze, 2011). During the last century due to the global climate change hydro meteorological parameters in the Black Sea coastal zone have changed. Before the early 1990s air temperature has been reduced by 0,2-0,3°C but during the last 16 years it increased by 0,2°C. Compared to 1960s precipitation increased by 13% in Poti, but decreased by 5% in Batumi. Similar to air temperature, sea temperature first decreased by 1°C and in 1990-2006 increased by 1,3°C resulting in cooling sea surface by 0.8°C compared to 1924 ("Second national", 2009; Giginishvili, Metreveli, Gzirishvili, & Beritashvili, 1999; Beritashvili, & Kapanadze, 2011, p.62].

Despite Georgian zone being the calmest in the Black Sea, at least once in 20 years it experiences a strong storm with speed exceeding 47m/sc (Supsa meteorological station). Wind of that power, mostly blown from the sea (70% of the cases) creates powerful storm and inblow ("Second national", 2009).

**Table 2.** Quantitative and percentage distribution of strong storms per years (1997-2007).

| Years | 4 –scale days | | 5 –scale days | | 6 –scale days | | 7 –scale days | |
|---|---|---|---|---|---|---|---|---|
| 1997-2007 | Quantity | % | Quantity | % | Quantity | % | Quantity | % |
| | 254 | 51,8 | 210 | 42,9 | 23 | 4,7 | 3 | 0,6 |

*Source:* "Second national", 2009.

One of the parameters also important for tourism development ---- comparative humidity --- was assessed in the coastal region as well. Assessment indicated that conditions are improving in Adjara while as per Poti meteorological station data comparative humidity here is continuing to increase.

The research conducted using regional model of climate changes PRECIS (Providing REgional Climates for Impacts Studies) ("The PRECIS", 2012) showed that by 2050 in the coastal zone of Black Sea, vicinity of city of Poti, air temperature is anticipated to increase by 1.2°C, with precipitation levels decreasing by 8-10%. In the coastal zone of Poti eustatic raise (relative sea level rise (RSLR) due to climate change) of sea level (Eustatic Sea Level, 2012; Carbognin, Tietini, Tomasin, & Tosi, 2010, p.1039) is in the process since 1925 and its speed reaches 1.7-2.0 mm/year. Because of this, by 2030-2050 absolute, eustatic increase of sea level will exceed 50 cm therefore reducing the height of dams protecting the city from inundation will decrease by further 17-22 cm, and increasing probability of flooding some of the city's districts significantly ($3 \leq p \leq 5\%$). Another aspect of climatic vulnerability of Poti is a degradation of coast, which has sharply activated at the conditions of sea eustatic process. ("Second national", 2009, p.146).

The anticipated change in climate parameters naturally will affect development of several sectors of economy in the coastal zone of Black Sea, with tourism being one of the most important ones, as noted above. Sea temperature has dropped by 0,8-1,0°C and recreational season has been reduced by 10 days

(Giginishvili, Metreveli, Gzirishvili, & Beritashvili, 1999). Water cooling may negatively affect population of fish (Black Sea sturgeon, mullet, mackerel, etc) and will reduce fishing volumes.

From the agricultural point of view, Kobuleti regions is the most perspective district of the coastal zone, where citruses (60% of Adjara's output), tea, aleurites, bamboo, etc. are successfully produced. From other crops corn and vegetables are cultivated here as well. In recent years hazelnut production has intensively been developed. On the background of projected climate changes by the middle of the century creation of better conditions for more warm-demanding plans is anticipated – for example, for the production of orange and lemon that will gradually push out tangerine, which is less profitable ("Second national", 2009). This will increase income from citruses twice. Increasing vegetation period from 224 to 290 days will make it possible to supply sea resorts with fresh vegetables during the entire year, while anticipated reduction in precipitation it will be necessary to use irrigating systems in April-May and partially in summer months.

At the relatively small territory of Georgia the relief diversity courses significant climate differences. Obviously, the climate conditions of the particular town could not be common for all others. That is way we studied the climate indicators on the background of global warming in Kutaisi, the largest city in the Western part of Georgia and generalize the results on surrounding regions. In Kutaisi and its nearby regions, situated away from the sea, average (multiyear) air temperature increased from 14,7°C to 15,1°C or by 0,4°C and it can be stated that this region, along with Telavi and Lentekhi, holds the second place in Georgia by increase, after Dedoplistskaro (0,6°C). However, we should note that starting from 1885 till now (during 125 years) average (annual) air temperature has exceeded 15°C 25 times, while lower temperature of 13,2°C-13,5°C was recorded 16 times.

Based on research by D. Mumladze (1991) it is accepted that air temperature increase in Georgia has reached its maximum in 1966-1975, mostly at the expense of winter temperatures. The results of our survey coinsided with Mumladze's estimations. During the period of our observation in Kutaisi year of 1966 was the hottest. This year, for the first time during the observation period, average air temperature reached 16,5°C largely due to the temperatures of winter months ---- December, January, February.

From 1957 till now maximum air temperature exceeding 40°C was recorded only 8 times. July 30, 2000 was the day when absolute maximum temperature reached 43,1°C. This is important since during 170 years of systematic observation 43°C was recorded only two times in Georgia. As of today sea zone, in particular Abkhazeti (Lata) and Adjara (Charnali) (Kordzakhia, 1961; *"Climate", 1971*; Mumladze, 1991; "First national", 1999) was joined by Imereti (Kutaisi), where, as stated above, 43,1°C was recorded on July 30, 2000. In general, from 1958 to 2006 maximum air temperatures exceeding 40°C were recorded only 7 times.

We have studied the year of 2010 separately. During this year, for the first time in the history of researched regions average air temperature reached 17,3°C. This was due to the fact that during the nine months average air temperatures have significantly exceeded 10°C and were varying between 13,4°C and 28,2°C. Only during the three months --- from January to March ---- variance was between 8,8°C and 9,9°C. Temperatures that high were accompanied by high relative humidity. Temperature of surface of the ground exceeded 50°C and 57-58°C were recorded in August. Humidity reached 70% and 87% in August. It is these conditions that facilitate increase of emergence of "heat islands" in the central districts of the city (Mikautadze, 1988).

Based on the data from the last ten years Kutaisi, especially in the summer days, is differentiated in Georgia by high average temperatures (Miqautadze, Davitulini, Bliadze, & Kvabziridze, 2011; Beritashvili, & Kapanadze, 2011). These high temperatures, as per our opinion, are determined mostly by local natural and landscape conditions and by fionic (local dry wind) circulations dominating Rioni river valley. Anthropogenic factors are to be considered here as well ("First national", 1999; "Second national", 2009). Much attention should be paid to the transport sector since auto transport will remain the largest emitter of greenhouse gases in Georgia for the next 20 years. It is expected that emission will increase from current 31% (in the energy sector emission) to 39% ("Second national", 2009, p.175). In the Georgian population trend to purchase large non fuel efficient transport vehicles is observed. Such increase will shift transportation sector to the first place within sectors depending on fossil fuel

("Second national", 2009, p.191). Therefore implementation of rightful transport policy becomes a necessity which includes changes in consumer choice and implementing technologies that facilitate fuel economy or use of alternative fuels. This is one of the opportunities to slow down future energy consumption from this sector, reduce environment pollution and diversification of energy consumption.

Pollution from auto transport and existence of dust in the air of course changes radiation background and water steam condensation conditions. In our opinion, the latter, in connection with fionic circulation, causes high temperatures observed in Kutaisi during the last 10-15 years.

As known, compared to air temperature distribution of atmospheric precipitation is characterized with greater dispersion. At each meteorological station in the region it is possible for the sum of precipitation to be significantly varied from regional average. It can be noted that on average precipitation increased by 10%, in particular by 13% in Poti and by 6% in Kutaisi (Beritashvili, & Kapanadze, 2011).

During the preparation of national communication for Framework Convention on Climate Change vulnerable regions to global warming were identified, first of all, Georgia's Black Sea coast. It is the most vulnerable ecosystem ("Second national", 2009). Therefore to soften impact of climate change it is necessary to inform local government periodically on the ongoing processes and their impact on the economy, since the climate change in the coastal region impacts: sea ecosystems, fishing, tourism sector, agriculture, local infrastructure: Kolkheti protected area, particularly Paliastomi lake. Since 1970 surface temperature on Paliastomi lake increased by 0,6°C ("Second national", 2009).

## Recommendations and Conclusions

According to the recommendations of the Framwork Convention on Climate Change the main adptaion measures for the Black Sea coastal zone the followings are considered:

- Permanent monitoring of raising sea levels and storm intensity and creation of early warning system for Poti segment;
- Coast protection works in the Rioni river delta;
- Estimation of climate change impart on tourism sector (heat, sea waves, water temperature, beach degradation) and planning of adaptation policies;
- Rehabilitation of salty and eroded soils.

As for Kutaisi area we consider, that the main adaptive measure should be reduction of greenhouse gas emission, which incorporates:

- Implementation of correct transportation policy;
- Using renewable energy sources (which the region is rich of- construction of 150 MW wind power station is planned in Kutaisi);
- Creation of environmentally friendly and energy efficient projects and putting clean development mechanisms in place.

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