

Advers Impacts of Climate Change on Biodiversity and Natural Disasters

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ABSTRACT

Reserved areas play vital role in preserving biodiversity and mitigating threats to climate change at local and world levels. Climate change that is already observed in many parts of the planet is the biggest and most horrible perspective facing our planet in near future. Adverse climate change processes are observed in Georgia too. In last decades biodiversity loss and increased natural disasters frequently take place. Scientists warn that if we will not be able to stop warming process at 1.50C we cannot be able to avoid unpredictable and irreversible consequences. Ecologists agree that enlargement of the existed reserved areas and creation of new ones will help to preserve biodiversity and mitigate climate change. They propose to enlarge the existed reserved areas up to 30% by 2030 and designate 20% of territory under strict monitoring [1]. At the same time we are sure that most of the local governments will not be happy by implementation of this idea and we believe that it must be supported and monitored by international nongovernmental organizations.

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Introduction

Reserved areas are the essential part of the ecosystems and play important function in biodiversity preservation and mitigation of climate change by means of reduction of greenhouse gas emissions and at the same time maintaining major services for people. These services include: food, water, mineral and medicine herb resources; water and air purification; carbon sequestration and climate regulation; pest and disease control; cultural and spiritual inspiration; recreation and scientific facilities. Reserved areas are good source of pure drinking water. Biodiversity of protected areas reduce their vulnerability against climate change [2].

According to World Bank Group terrestrial protected areas in 2016 were 14.557% and in 2017-2018 increased to 14.732 % [3]. The present world with threats to biodiversity loss and changing climate reserved areas are much more important for biodiversity conservation and climate mitigation than they ever been before. Reserved areas, forests and other vegetation of terrestrial ecosystems mitigate climate change by absorbing carbon dioxide and in contrary they contribute adversely to climate change when they are destroyed and degraded [4].

According to the climate scenarios for future existing reserved areas will not be able to carry out their protecting role and substantial expansion of their network will be necessary to help species to adapt to climatic change. Climatic change is much more than only temperature change as biodiversity is confronted with changing rainfall, declining water balance, increased extreme climate events. Some decades ago climate change seemed very distant and less certain, but the late periods showed that we were

mistaken. Climate change is already evident in such ecological changes as in phenology and species range. Some trees and bushes are blooming now earlier than before other species are shifting their range directions [5,6]. Scientists think that these processes accelerate more with further climate change, resulting in serious changes of biodiversity in future.

Climate change has already affected on climate processes and biodiversity. It is obvious in atmospheric concentrations of carbon dioxide, increased land and ocean temperatures, amount and frequency of annual precipitations and sea level rise [6,7]. It have already affected on timing of reproduction and migration of animals and length of growing seasons, distribution of species and frequency of pest and disease outbreaks. Particularly vulnerable are high mountain ecosystems. Many species there are already under threat of extinction. High elevation mountain ranges are warming faster than lowlands and it will have adverse affect on hydrological and ecological processes that will result in loss of biodiversity, as well as of many environmental goods and services like water supply, basin regulation and hydropower potential [8]. Proper land use and sustainable forest activities can play important role in reducing net greenhouse gas emissions to the atmosphere, as well as by reforestation, afforestation and substitution of fossil fuel energy by use of biomass, solar, wind and geothermal energy [9].

Results and Analysis

Biodiversity of Georgia is noted on regional and global levels. Georgia as a part of the Caucasus eco-region, represents one of the 34 biodiversity „hotspots” identified by Conservation International [9] as area distinguished for richness of its species and distinct biological components, complex of landscapes, variation of climate and diverse ecosystems. The main biomass in Georgia are: forests, wetlands, marine and coastal habitats, high

mountains, semi-deserts and steppes [10,11]. Especially must be noted Kolkheti plain, high mountain ecosystems and limestone of the Western Caucasus notable for their diverse species and endemism. Georgia's flora is one of the richest among countries of moderate climate with 4,130 vascular plant species. Georgia has 300 native vascular plant endemics and 600 more endemics for the Caucasus region. The central and eastern parts of the Caucasus mountain range are particularly rich with endemics. About 2,000 species of Georgia's flora have economic value utilized as timber, firewood, food (wild fruit and nuts, wild berries), forage and animal food, medicine herbs, condiments and some biomass components used in perfumery.

Among Caucasian endemics there are 19 mammals, 3 birds, 15 reptiles and 3 amphibians. The diversity of species of living organisms is very high in Georgia. There are 44 species of fish, 12 species of amphibians, 52 species of reptiles, more than 300 species of birds and 109 species of mammals [12, 13]. Georgia's agricultural biodiversity of endemic animals and agricultural plants is very rich. Many species of grapes and grains are considered the cradles of their origin.

Due to habitat destruction and unregulated exploitation many plant and animal species are endangered and included in the Red List [13-15]. For the lack of effective methods of data collection, identification of real changes of species and habitat conditions are difficult. Therefore assessment and current state of biodiversity is very complicated. Consequently it raises difficulties in decision making of biodiversity conservation.

In tables 1 and 2 are given: number of plant and animal species and endangered species by taxonomic groups and number of threatened species within the various taxonomic groups of vertebrates. From these tables we see that number of species included in the Red List of Georgia by IUCN categories, especially concerning are: vulnerable vascular plants (36), invertebrates (32), birds (24), mammals (18), reptiles (8), and fishes (7). From Endangered species must be underlined: vascular plant species (18), birds (9), invertebrates (8), mammals (6), and fishes (6). Critically endangered are: mammals (5), vascular plants, invertebrates and birds (by 2 of each). As to the number of threatened species within the various taxonomic groups of vertebrates, especially alarming are: birds, mammals, fishes and reptiles. The total number of threatened species were 105 in 1996, 92 in 2003 and 2006 that is 13.8% and 12.2 % from all species accordingly.

Table 1: Number of Plant and Animal Species and Endangered Species by taxonomic groups

Taxonomic group	Number of species	Number of species in IUCN Red List as VU or higher category	Number of species included in the Red List of Georgia(According to IUCN categories)			
			NE	CR	EN	VU
Plants:						
Algae	2,605					
Mushrooms	7,000					
Lichens	800					
Mosses	812					
Vascular Plants	4,130		-	2	18	36
Animals	-					
Invertebrates	15,761	6	-	2	8	32
Fishes	188	10	-	1	6	7
Amphibians	13	1	-	-	1	1
Reptiles	54	11	-	1	2	8
Birds	390	14	-	2	9	24
Mammals	111	8	4	5	6	18

Sources: Red List of Georgia. momxmarebeli.ge
The IUCN Red List of Threatened Species. iucnredlist.org

Table 2: Number of threatened species within the various taxonomic groups of vertebrates

Taxon/year	1982	1996	2003	2006
Fishes	1	7	1	11
Amphibians	4	2	4	2
Reptiles	6	28	6	11
Birds	33	34	55	35
Mammals	21	34	26	33
Total	65	105	92	92
Share of threatened species	8.6%	13.8%	12.2%	12.2%

Sources: Conservation International. conservation.org
The IUCN Red List of threatened species. iucnredlist.org

The main threats to biodiversity are degradation and destruction of habitats and extensive use of biological resources. The major courses of habitat degradation are logging, intensive grazing and degradation of water ecosystems [16-19]. Despite decrease of legal and illegal extraction of forest resources, wood and firewood utilization remain the principal threats to biodiversity. Grazing is also remain problematic in sub-alpine and alpine ecosystems, as well as in semi-arid zones in south-east parts of Georgia were it is resulted in soil erosion. In spite of the fact that hunting is permitted only in hunting farms poaching (including fishing) is considered the main reason of decrease of the populations of deer, Caucasian goat, chamois, wild oat bear and several species of fish. Construction of new dams along the migration routes are impassable barrier for some fish moving to spawning areas. Extraction of non-timber forest resources (wild fruit, barriers, mushrooms, condiments, medicine herbs and other bio resources) are not legally regulated and it is also the reason of biodiversity loss.

It must be underlined that current level and condition of biodiversity conservation in Georgia after breakup of the Soviet

system was preserved due to the reserved areas developed in that period. The first nature reserve was established in Georgia in 1912 in Lagodekhi (kakheti region). In the Soviet period totally were created 14 strict nature reserves and 5 forestry-hunting reserves [20, 21]. Due attention was not towards other species or ecosystems. The objectives for establishment of nature reserves were not correctly identified. That's why majority of Georgian nature reserves are characterized by low ecological efficiency. From 2013 new reserved areas according to IUCN categories have been organized [20, 21]. Besides strict nature reserves were established: national parks, natural monuments, habitat/species management areas and protected landscapes. Today there are 86 reserved categories with total area of 595,963 hectare among them: 14 strict nature reserves, 11 national parks, 40 nature monuments, 19 habitat/species management area and 2 protected landscape (Table 3). It is about 7% from the total territory of Georgia (without occupied by Russia territories of Abkhazeti and Samachablo that is 20% from the former territory of Georgia before occupation). Unfortunately the reserved areas weren't enlarged from 2013, thou there are many possibilities.

Table 3: The Reserved Areas of Georgia According to the Categories of the International Union for Conservation of Nature and Natural Resources (IUCN)

Type of protected area	2014		2015		2016		2017		2018	
	Area	Number	Area	Number	Area	Number	Area	Number	Area	Number
Strict nature reserve	140,672	14	140,672	14	139,049	14	139,049	14	139,049	14
National park	352,566	11	350,385	11	349,327	11	347,927	11	347,921	11
Nature monument	2,378	41	2,378	41	2,932	42	2,941	42	2,754	40
Habitat/Species management area	70,393	19	70,266	19	71,530	19	71,530	19	71,530	19
Protected landscape, Seascape	34,708	2	34,708	2	34,708	2	34,708	2	34,708	2
Total	600,717	87	598,409	87	597,547	88	596,156	88	595,963	86

Sources: Natural Resources of Georgia and Environment Protection. Statistical Publication: 2014, 2015, 2016, 2017, 2018

Today the main goals of reserved areas are: to maintain watersheds and water retention in soils; limit land-use transformation; reduce other pressures such as poaching, grazing, logging and harvesting within their boundaries; help to reduce impacts of extreme climatic events like storms, floods, droughts; provide space for floodwaters to disperse and absorb impact with natural vegetation; help to mitigate effects of climate change by capture and storage of CO₂ from atmosphere [22]. To achieve these goals the effective measures are necessary such as reforestation and protection of forest ecosystems which provide high biomass and carbon storage. So, long-term protection provided by existed reserved areas and establishing new once will help to increase carbon storage [23].

Table 4: Number of occurred geological phenomena (landslide, mudflow), human casualties and vulnerable objects (unit)

Year	Landslide		Mudflow		Vulnerable objects		
	Number of landslides (activated or newly occurred)	Number of human casualties	Number of mudflows (activated or newly occurred)	Number of human casualties	Affected agricultural land(hectare)	Number of human settlements	Number of buildings
1995	670	6	250	12	179	274	195
1997	871	2	335	7	337	458	227
2000	65	1	23	-	162	240	207
2004	949	4	258	2	16,289	1,755	6,042
2005	603	-	155	4	7,590	473	3,682
2009	323	1	193	3	8,232	521	2,696
2010	250	3	81	2	1,155	366	822
2014	727	-	141	10	-	1,041	962
2015	936	4	167	19	-	931	1,014
2016	780	-	208	-	-	1,421	1,084

2017	845	-	165	-	-	1,587	1,353
2018	702	1	122	-	-	1,644	1,245

Source: Ministry of Environment Protection and Agriculture of Georgia
LEPL National Environmental Agency

In tables 4, 5 and 6 are given: The number of occurred geological phenomena (landslide, mudflow); human casualties and vulnerable objects; number of occurred hydro meteorological hazards and revealed violations of law related to environmental protection by regions and violation types in 2018. These tables show that from 1995 number of landslides from 670 increased to 702 in 2018, thou in 2004 and 2015 increased to 949 and 936 accordingly. The number of vulnerable human settlements increased from 274 in 1995 to 1644 in 2018 and number of vulnerable buildings from 195 in 1995 to 1245 in 2018 (Table4). Number of floods and flash floods increased from 8 in 2013 to 36 in 2017. The number of hurricanes and squall from 20 in 2013 increased to 25 in 2017 and avalanches from 8 to 18 in the same years (Table 5). Violation of laws are especially high in illegal loggings, illegal mining, atmospheric air legislation, fishing and violation concerning environment pollution by waste disposal (Table 6).

Table 5: Number of occurred hydro- meteorological hazards in 2013-2018 (unit)

Hydro-meteorological hazard	January	February	March	April	May	June	July	August	September	October	November	December	Total
2013													
Flood & Flash flood	-	-	-	-	1	2	1	2	1	-	-	1	8
Hurricane & Squall	-	-	3	1	1	3	2	1	2	1	3	3	20
Hail	-	-	2	3	6	5	3	4	-	-	-	-	23
Heavy snow+	-	-	-	-	-	-	-	-	-	-	-	-	-
Avalanche	1	2	2	1	-	-	-	-	-	-	-	2	8
2014													
Flood & flesh flood	-	-	-	2	1	2	3	4	7	1	1	-	21
Hurricane & Squall	-	3	2	1	3	8	2	2	6	5	2	-	34
Hail	-	-	-	3	8	10	1	3	3	-	-	-	28
Heavy snow	-	-	-	-	-	-	-	-	-	-	-	-	-
Avalanche	3	-	1	-	-	-	-	-	-	-	-	-	4
2015													
Flood & Flesh flood	-	-	-	1	2	4	1	-	-	1	1	-	10
Hurricane & Squall	2	1	-	-	-	-	-	-	-	-	4	2	9
Hail	-	-	-	2	6	9	3	1	-	1	-	-	22
Heavy snow	2	-	-	-	-	-	-	-	-	-	-	-	2
Avalanche	3	-	-	-	-	-	-	-	-	-	-	-	3
2016													
Flood & Flash flood	1	-	-	1	-	5	15	1	2	-	-	1	26
Hurricane & Squall	-	4	1	5	-	2	1	4	4	-	-	-	23
Hail	-	-	-	-	16	11	3	4	-	2	-	-	36
Heavy snow	8	-	1	-	-	-	-	-	-	1	2	4	16
Avalanche	-	-	-	-	1	-	-	-	-	-	1	3	5
2017													
Flood & Flash flood	-	-	-	-	8	6	10	2	4	5	-	1	36
Hurricane & Squall	2	2	3	4	2	2	2	2	2	2	-	2	25
Hail	-	-	-	1	9	3	4	-	2	-	-	-	19
Heavy snow	2	-	-	-	-	-	-	-	-	-	-	-	2
Avalanche	4	4	4	1	2	-	-	-	-	-	-	3	18
2018													
Flood & Flash flood	1	-	-	-	-	6	2	2	1	1	-	-	13
Hurricane & Squall	1	-	1	1	-	-	-	1	-	1	-	1	6
Hail	-	-	1	-	4	1	-	2	2	-	-	-	10
Heavy snow	-	-	-	-	-	-	-	-	-	-	-	-	-
Avalanche	!	-	-	-	-	-	-	-	-	-	-	-	1

Sources: Ministry of Environment Protection and Agriculture of Georgia;
LEPL National Environmental Agency.

The protected areas of Georgia play important role in mitigation and adaptation to the climate change. They store significant amount of carbon, increase resilience and reduce vulnerability of livelihoods against climate change. Mountain protected ecosystems buffer local climate and help to protect local communities, reduce the impact of natural disasters. Protected areas in the high mountains defend the local population from snow-slips, snow-storms, avalanches, mud streams, torrents and landslides [23,24].

Table 6: Revealed violations of law related to environmental protection by regions and violation types, 2018 (unit)

Region	Illegal Loggings	Violation of fishing rules	Violation of hunting rules	Illegal mining	Violation of atmospheric Air legislation	Violation of water legislation	Violation of land legislation	Pollution of environment by waste disposal	Other violations
Georgia, Total	1282	341	217	1132	797	275	198	573	299
Tbilisi	2	22	8	3	118	5	14	113	28
Adjara AR	269	16	13	359	108	68	12	85	22
Guria	11	24	24	60	8	4	7	7	27
Imareti	82	51	58	462	183	42	45	47	35
Kakheti	431	42	44	96	105	18	14	33	30
Mtskheta-Mtianeti	10	28	22	14	28	24	15	43	20
Racha-Lechkhumi and Kvemo Svaneti	16	-	3	11	19	9	4	32	22
Samegrelo-Zemo Svaneti	87	41	3	47	66	42	24	48	23
Samtskhe-Javakheti	268	22	8	23	30	35	38	40	30
Kvemo Kartli	50	57	23	34	81	13	16	104	31
Shida Kartli	56	38	11	23	51	15	9	21	31

Sources: Ministry of Environmental Protection and Agriculture of Georgia; Environmental Supervision Department; LEPL National Agency of Mines.

Georgia entered to the United Framework Convention on Climate Change (UNFCCC) in 1994 and in 2006-2009 worked out the second national notification to the convention. In this process scenarios of expected climate change and vulnerability of various ecosystems and expected changes were evaluated. At the same time plans for reduction of green-house gas emissions were developed. Three regions: the black sea coast, Dedoplistskaro district and Kvemo Svaneti have been assessed using identified vulnerability and adaptation measures. Evaluation showed that the vulnerable sectors are Rioni and Chorokhi rivers. The rise of sea water level has significant negative impact on the protected areas, particularly on Paliastomi Lake. The temperature from 1927 to 2006 had arisen by 0.70C and it resulted in serious changes of lake's ecosystem.

Dedoflistskaro region in the south-east part of the country is rich by fertile soils and pastures. The region is represented by unique semi-arid ecosystems. The total area of protected territories is about 30,552 hectare or 12% of the district. Among protected areas there are: Vashlovani national park, nature reserve and natural monuments: Alazani floodplain, Artvisi gorge and Chachuna state reserve. Agriculture plays leading role in the economy of the region, but seriously impeded by lack of water resources, frequent droughts and strong winds. Soil degradation is one of the acute problems. Erosive processes of the local pastures are intensified that has adverse impact on vegetation.

Next region of Kvemo Svaneti, a mountainous region was selected as a ecosystem with vulnerability to natural disasters that is intensified by the threat of global warming. Increase and intensification of flash-floods, landslides and mudflows extremely damages agriculture, forests, roads and other infrastructure. Evaluation of the glaciers in the Central Caucasus region showed that their total area decreased by about 25% whilst the total volume

diminished from 1.2 km³ to 0.8 km³ since 1950s. The predicted increase of temperature in near future threatens vanishing of Kvemo Svaneti glaciers.

Conclusions

The reserved areas of Georgia played very important role in the Soviet period. They had high conservative value and due to their presence many species have been preserved and saved from extinction. The populations of rare and endangered species (endemics among them) have been preserved and survived due to reserved areas. In 2013 Georgia became a member of IUCN and reserved areas were reorganized according to their categories. Presently there are 86 reserved areas, among them: 14 strict nature reserve, 11 national park 40 nature monument, 19 habitat/species management area and 2 protected landscape. From the Soviet period territory of reserved areas increased from 2.4% to 7% of the country's territory. But taking into account the accelerated rate of climate change we believe that it will not be enough and expansion of reserved areas will be necessary by 2030 up to 30%. It will help to increase ecosystems' resilience, biodiversity preservation, save endangered species from extinction and mitigate climate change. All these challenges will require new ecosystem management aiming multiple biodiversity and ecosystem goals. These problems concern not only local territories they are international and require regional collaboration in management. International management strategies are necessary to identify, monitor and jointly manage species and habitats vulnerable to climate change.

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