The Project: Institutionalization of Climate Change Adaptation and Mitigation in Georgia Regions Project (ICCAMGR)

Climate Change Indicators Description

1. Background

United States Agency for International Development/Caucasus (USAID/Caucasus) and the National Association of Local Authorities of Georgia (NALAG) in 2012 signed a cooperative agreement to provide support for the Institutionalization of Climate Change Adaptation and Mitigation in Georgia Regions Project (ICCAMGR).

Among other components of the project is the *Road Map on Climate Change,* which included 10 supplementary project proposals for potential and future implementation by the municipal self-government units. The Road Map is a policy mechanism to highlight the economic problems related to climate change within the Georgian municipalities and provide concrete recommendations to national policy makers. It will provide beneficiary municipalities with a comprehensive reference document, which will support their strategic planning activities and future efforts to work with national policy makers to adapt to climate change and mitigate its risks in their relevant municipalities.

ICCAMGR selected the *ESPON Climate Change and Territorial Effects on Regions and Local Economies* as a guiding research methodology, available via http://www.espon.eu/export/sites/default/Documents/Projects/AppliedResearch/CLIMATE/ESPON_Climate_Final_Report-Part_C-ScientificReport.pdf, for the *Road Map*. Therefore, the *Road Map* will analyse the following sectors sensitive to climate change:

- Physical infrastructure (roads, railroads, harbours, airports, settlements, etc.);
- Social sensitivity (health)
- Agriculture (including water availability for the sector, drainage/irrigation);
- Industry (mostly secondary sector of economy and mining);
- Tourism (will cover, protected areas and cultural heritage);
- Energy.

For each sector, one to two quantitative sensitivity indicators were selected based on a) abovementioned ESPON Report, b) differed country specifics, and c) official quantitative information availability per each municipality for same indicator. Below find:

1. Short description of correlation of each sensitivity indicator with climate exposure indicators, and
2. Correlation table of indicators selected.

At the later stage of the Road Map elaboration, on the basis on quantitative information collected for mapping and further spatial analysis purposed for each indicator quantitative ratio indexes will be identified.

Sensitivity Indicators

2. Physical Sensitivity indicators prone Natural Hazards triggered by climate change exposure:

One of the most important components of the risk assessment is the exposure analysis. The interaction between different elements at risk and the potential hazards directly defines the level of exposure. Physical vulnerability is essentially the potential for physical impact on the built environment and population. It is defined as the degree of potential loss, to a given element-at-risk or set of elements-at-risk, resulting from the occurrence of a natural phenomenon of a given magnitude.

2.1. Primary Physical Sensitivity:

1. *Settlements sensitive to landslides, debris-flows, flash floods, floods and other natural disasters* – physical vulnerability of settlements will be calculated based on different natural disaster information. Relative change in annual mean precipitation, Change in number of days with heavy rainfall, change in annual mean number of days with snow cover and depth triggers different kind of natural disasters (landslides, debris-flows/mudflows, flash-floods, floods et. al), which causes damages of settlements.

2.2. Physical Sensitivity to be considered under corresponding sectors:

1. *Roads and railways sensitive to landslides, debris-flows, flash floods, floods and other natural disasters* – Physical vulnerability of road and railway infrastructure will be calculated. Relative change in annual mean precipitation, change in number of days with heavy rainfall, change in annual mean number of days with snow cover and its depth triggers different kind of natural disasters (landslides, debris-flows/mudflows. flash-floods, floods et. al), which causes damages of roads, railway and other infrastructure.
2. *Airport and harbours sensitive to landslides, debris-flows, flash floods, floods and other natural disasters* – Based of natural hazards information, vulnerability of airports and harbours will be calculated.
3. *Cultural World Heritage Sites (including tentative list) sensitive to different natural hazards (landslides, debris-flows, floods, flash-floods, snow avalanches, sea level rise et. al)* – based of natural hazards information, physical vulnerability of cultural sites will be calculated.
4. *Museums sensitive to different natural hazards (landslides, debris-flows, floods, flash-floods, snow avalanches, sea level rise et. al)* - based of natural hazards information, physical vulnerability of cultural sites will be calculated.
5. *Other physical infrastructure sensitivity to natural disasters* - Physical vulnerability of infrastructure will be calculated based on Natural disaster information.
6. *Industrial objects sensitivity to landslides, debris-flows, and flash-floods* - Physical vulnerability of industrial infrastructure will be calculated based on natural disaster information.

2.3. Climate Exposure Affect on Natural Hazards

1. *Relative change in annual mean precipitation* **–** will be calculated based on data the climate-modeling expert will provide. Change of annual mean precipitation will be used as indicator as one the triggering factor for landslide, debris-flow, flash-flood, and flood occurrence.
2. *Change in number of days with heavy rainfall* - will be calculated based on data the climate-modeling expert will provide. Change of number of days with heavy rainfall will be used as indicator as one the triggering factor for debris-flow/mudflow, flashflood, and flood occurrence.

3. *Change in annual mean number of days with snow cover and change in snow cover depth* - will be calculated based on data the climate modeling expert will provide. These data will be used as indicator for snow avalanche hazard.

Table 1: Correlation table of climate exposure indicators triggering natural hazards

	Change in annual mean temperatures	Extreme temperatures	Change in annual mean number of summer days	Relative change in annual mean precipitation in winter months	Relative change in annual mean precipitation in summer month	Relative change in annual mean precipitation	Change in annual mean number of days with heavy rainfall	Relative change un annual mean evaporation	Change in annual mean CDSC depth	Change in annual mean number of days with snow cover CDSC
Natural Hazards										
Landslides				X	X	X				
Debris-flows/mudflows, flashfloods						X	X			
River floods						X	X			
Snow avalanche									X	X

3. Social Sensitivity Indicators:

Climate change will affect different age groups of population through diverse effects. Under the given document the following indicators, divided into two groups, were selected:

3.1. Primary Social Sensitivity:

1. *Population sensitive to summer heat* - This component itself will be assessed by combination of two data source: population of municipality over 65 (men, women), and population of municipality under poverty level (men, women). Thus, indicator is considered to be linked with change in extreme temperatures (max), and change in annual mean number of summer days.
2. *Population sensitive to different climate exposure indicators* - This component itself contains data on climate-sensitive diseases – cardio-vascular diseases (hypertension), vector-born disease. Both will be linked to change in extreme temperatures (max and min), and change in annual mean number of summer days.

3.2. Social Sensitivity under Industrial Sector

3. *Employees sensitive to summer heat* – It will be assessed as the number of employees per municipality over 65. The indicator is considered to be linked with change in extreme temperatures (max), and change in annual mean number of summer days.

4. Tourism Sensitivity Indicators:

For the purpose of this study under the tourism sector the following aspects will be considered as sensitive to climate change: a) Primary sensitivity of tourism industry, and b) Sensitivity of touristic attractions of the country: cultural heritage and protected areas. During indicators selection selection methodology of ESPON report was considered, relevant to the conditions in Georgia – local climatic zones are the same as in Europe, and the character of Georgian tourism is close to the European one. Georgian tourism can as well be divided into two categories: winter tourism (Bakuriani, Gudauri, Mestia, in perspective – Mountainous Adjara and Mountainous Guria) and summer tourism (all destinations not associated with winter tourism). Accordingly, the following indicators were selected:

4.1. Primary sensitivity of tourism industry

1. *For summer tourism sensitive to summer temperatures* – relative change in annual mean precipitation in summer months will economically affect the sector;
2. *For winter tourism sensitive to snow cover changes* – change in annual mean number of days with snow cover (CDSC) and change of snow cover depth will also economically affect the sector.

4.2. Sensitivity of touristic attractions of the country

4.2.1. Protected areas' sensitivity:

3. Similarly to ESPON report, under current study, it's assumed that all climate change exposure and trigger indicators will affect protected areas[1].

4.2.2. Cultural heritage sensitivity:

For purposes of this study cultural heritage is divided into following sections:
(a) UNESCO Cultural World Heritage Sites (including tentative list),
(b) National Cultural Heritage Sites, and
(c) Museums.
Therefore, cultural heritage sensitivity indicators will include the following:

4. *UNESCO Cultural World Heritage Sites (including tentative list) sensitive to different natural hazards (landslides, debris-flows, floods, flash-floods, snow avalanches, sea level rise et. al)* – based of natural hazards information, physical vulnerability of cultural sites will be calculated.
5. *National Cultural Heritage Sites sensitive to different natural hazards (landslides, debris-flows, floods, flash-floods, snow avalanches, sea level rise et. al)* – based of natural hazards information, physical vulnerability of cultural sites will be calculated.
6. *Museums sensitive to different natural hazards (landslides, debris-flows, floods, flash-floods, snow avalanches, sea level rise et. al)* - based of natural hazards information, physical vulnerability of cultural sites will be calculated.

[1] However, under narrative text per each municipality specifics of particular protected areas will be considered

5. Agriculture Sensitivity

Based on available information for the agricultural sector the following sensitivity indicators were identified:

5.1. Agriculture industry sensitivity to state of irrigation and drainage:

Primary sensitivity indicators of industry under irrigation and drainage:

1. The ratio of irrigated and dried land to the total area. The irrigated areas out of the total water ensured areas would be evaluated. The land utilization coefficient of irrigated area will be established.
2. The assessment of vulnerability of irrigation and drainage melioration systems on the agricultural land. The reliability and risk of melioration systems will be defined based on statistic and field data.

Correlation of primary sensitivity indicators of industry under irrigation and drainage with climate exposure indicators:

1. The ratio of actual precipitation amount and water demand of plant during the vegetation period (April-October) in climate change conditions. The negative impact on soil (erosion, salinization) in case of excessive irrigation will be assessed.
2. The temperature regime change during the plant vegetation period taking into consideration the fact of climate change. New irrigation norms will be established and gross consumption of irrigation water identified.

5.2. Agriculture industry sensitive to soil productivity:

3. Against the backdrop of climate change, soil fertility and land use will be considered taking into account the agro-technical measures and change of soils mean annual relative evaporation.

5.3. Forestry sector sensitive to forest fires:

4. In view of the climate change, forest sensitivity and fires forecast will be considered for each municipality separately, where the value of extreme temperatures in forest areas, change of the summer days number and the relative change of the seasonal annual precipitation will be taken into account.

6. Energy Sector Sensitivity

For the purpose of this study under the energy sector the following aspects will be considered as sensitive to climate change: 1. Primary social sensitivity of energy consumption end energy loads due to change in average and extreme summer and winter temperatures 2. Secondary sensitivity due to local aspects of energy industry vulnerability

6.1 Primary Social Sensitivity of Energy Consumption and Extreme Loads

Energy Consumption sensitivity will be assessed based on the change of energy demand for heating and for cooling. Therefore, as a slight refinement to existing model study:

1. *Projections for heating degree days (HDD)* will be used to assess the change in heating energy consumption
2. *Projections for cooling degree days (CDD)* will be used to assess the change in cooling energy consumption, in addition,
3. *The change in extreme temperatures will pose additional demand heating and cooling load and energy performance of dwellings*. Therefore the projections of hottest and coldest temperatures will be used to assess an effect on required capacity of heating and cooling equipment and thermal insulation of building enclosure.

6.2. Sensitivity through effects on Energy Industry

Secondary sensitivity due to local aspects of energy industry vulnerability may be assessed based on information on energy infrastructure and information on

- Natural disasters
- Changes in hydrology regimes
- Changes in extreme temperatures

7. Industry Sensitivity (mostly secondary sector of economy and mining)[2]

Under the industrial sensitivity the following indicators will be considered:

1. *Industrial objects sensitivity to landslide, debris-flow, flashfloods* – Physical vulnerability of industrial objects will be calculated based on natural disaster information;
2. *Roads and railways (as economic development support infrastructure) sensitive to landslides, debris-flows, flash floods, floods and other natural disasters* – Physical vulnerability of road and railway infrastructure will be calculated. Relative change in annual mean precipitation, change in number of days with heavy rainfall, change in annual mean number of days with snow cover and its depth triggers different kind of natural disasters (landslides, debris-flows/mudflows. flashfloods, floods et. al), which causes damages of roads, railway and other infrastructure;
3. *Airport and harbors (as economic development support infrastructure) sensitive to landslides, debris-flows, flash floods, floods and other natural disasters* – Based of natural hazards information, vulnerability of airport and harbors will be calculated.
4. *Employees sensitive to summer heat* – It will be assessed as the number of employees per municipality over 65. The indicator is considered to be linked with change in extreme temperatures (max), and change in annual mean number of summer days.

[2] Under the industry tourism, energy, agriculture, as primary sector of economy, will not be considered. Moreover, due to lack of spatial data about sector results of analysis under some indicators might not be mapped.

Overview of sensitivity indicators in relation to exposure indicators

		Change in annual mean temperature	Change in seasonal mean temperature	Change in extreme temperatures (max. & min.)	Change in annual mean number of summer days	Change in annual mean number of winter days	Change in annual mean number of frost days	Relative change in annual mean precipitation	Relative change in seasonal mean precipitation	Change in annual mean number of days with heavy rainfall	Relative change in annual mean evaporation	Change in annual mean snow cover (CDSC) depth	Change in annual mean number of days with snow cover CDSC	Trigger Climate effects: Change of mean sea level
Physical sensitivity														
1.	Settlements sensitive to landslides, debris-flows, flash floods, floods and other natural disasters							x	x	x		x	x	
2.	Roads and railways landslides, debris-flows, flash floods, floods and other natural disasters							x	x	x		x	x	
3.	Airports and harbours sensitive to landslides, debris-flows, flash floods, floods and other natural disasters							x	x	x				
4.	Settlements sensitive to coastal flooding													x
5.	Roads and railways sensitive to coastal flooding													x
6.	Airports and harbours sensitive to coastal flooding													x
	Social Sensitivity													
7.	Population sensitive to summer heat			x	x									
8.	Population sensitive to different climate exposure indicators (social sensitivity)			x	x									
Agricultural sensitivity														
9.	Agriculture sensitivity to state of irrigation and drainage	x	x					x	x		x			
10.	Forestry sensitive to forest fires			x	x			x	x					
11.	Agriculture sensitive to soil productivity										x			
Tourism sensitivity														
12.	Summer tourism sensitive to summer temperatures								x					
13.	Winter tourism sensitive to snow cover changes											x	x	
14.	Protected natural areas sensitive to different exposure indicators	x	x	x	x	x	x	x	x	x	x	x	x	x

		Change in annual mean temperature	Change in seasonal mean temperature	Change in extreme temperatures (max. & min.)	Change in annual mean number of summer days	Change in annual mean number of winter days	Change in annual mean number of frost days	Relative change in annual mean precipitation	Relative change in seasonal mean precipitation	Change in annual mean number of days with heavy rainfall	Relative change in annual mean evaporation	Change in annual mean snow cover (CDSC) depth	Change in annual mean number of days with snow cover CDSC	Trigger Climate effects: Change of mean sea level
15.	UNESCO Cultural World Heritage Sites (including tentative list) sensitive to landslides, debris flows, flash-floods, river flooding							X	X	X				
16.	UNESCO Cultural World Heritage Sites (including tentative list) sensitive to coastal flooding							X	X	X				X
17.	Museums sensitive to landslide, debris flows, flash-floods, river flooding, river flooding							X	X	X				
18.	Museums sensitive to sea level rise							X	X	X				X
Energy sector sensitivity														
19.	Energy demand correlated to summer heat (CDD); Sensitivity Indicator				X									
20.	Energy demand correlated to winter frost (HDD); Sensitivity Indicator					X	X							
21.	Cooling load			X										
22.	Heating load			X										
23.	Energy supply sensitive due to changing river water levels.								X*					
24.	Industry sensitivity due to changing river hydrology								X*					
25.	Physical infrastructure sensitivity due to summer heat.			X										
26.	Physical infrastructure sensitivity to natural disasters.							X	X	X		X	X	X
Industrial sector sensitivity														
27.	Industrial objects sensitivity prone to landslide, debris flow, flash floods, river flooding							X	X	X				
28.	Industrial objects sensitivity prone to coastal flooding							X	X	X				X
29.	Employees sensitive to summer heat			X	X									