Assessment of the impact of expected climate changes on the population of Azerbaijan and possible adaptation to them

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A number of studies on assessment of the expected climate change impacts on the environment and population of Azerbaijan have been conducted in Azerbaijan over the last 10-15 years [1-5, etc.]. Assessments were made based on the scenarios most closely resembling conditions in the country: *GISS, GFDL-3, expert* [1,2] *and PRECIS 1.4* [3-5] which reflected various alternatives of climate change. The scenarios were designed for the period of double CO2 content of atmospheric air, and *PRECIS 1.4* was designed for two periods: 2021-2050 /I/ and 2071-2100 /II/. According to these scenarios, 1.5 to 6.0^{0}C change of the average yearly air temperature is expected in various regions of Azerbaijan as compared with the reference period (1961-1990).

Annual precipitation will undergo multidirectional changes: from +4 (+40%) to -1 (-5%) (Table 1).

Table 1. Expected changes in annual air temperature norm

(^{0}C) and atmospheric precipitation (percentage ratio to the reference period)

Climatic element	Scenarios				
	GISS	GFDL-3	Exp.	PRECIS 1.4	
				2021-2050 **/I/**	2071-2100 **/II/**

Air temperature, ^0C	4.3-4.4	4.2-4.4	2.0	1.5-1.6	3.0-6.0
atmospheric precipitation ,%	6-12	-5 - +4	0	0 – 20	-20 - +40

Expected changes of climatic indices which have a direct impact on the natural environment and population were calculated based on the abovementioned scenarios.

Agroclimatic resources

Current status

Heat resources. There are 3 zones of plants heat supply in the territory of the country according to [6,7]:

Thermal zone - $\sum t > 10^\circ$ - $> 3800^\circ$

Temperate zone - $\sum t > 10^\circ$- 3800° - 800° (1000°)

Frigid zone - $\sum t > 10^\circ$ - $<800^\circ$ (1000°),

where $\sum t > 10^\circ$ is the sum of active temperatures (effective heat sum above 10^0C).

The upper limits of these zones in the mountainous territory are at 400 – 1250 m above sea level (thermal zone) and 2280 – 2800 m above sea level (temperate zone).

It should be noted that heat resources vary within a wide range both in the temperate and thermal zones reaching 4800° and more in some regions of the central part of the Kura-Aras Lowland and peri-Aras plains of the Nakhchivan Autonomous Republic.

Moisture resources. Annual atmospheric precipitation ranges from 200 to 1900 mm and the most part of them (50-75%) falls in the warm season. However, in lowlands and lower parts of submontane regions, precipitation is light as compared with the plants water demand, that's why semiarid and dry steppe natural zones form there and cropping necessarily requires artificial irrigation. Climatic irrigation norm is determined by comparison of available inherent moisture with the potential evaporation discharge (atmospheric precipitation minus evaporability). Its annual discharge in central parts of the Kura-Aras Lowland and low-hill terrains of the Nakhchivan AR reaches 1000-1300 mm (from 10,000 to 13,1000 m^3/ha) and above.

An essential characteristic of natural irrigation conditions is moisture factors determined mainly by atmospheric precipitation/evaporability value calculated by various methods.

Most of agroclimatic studies conducted in Azerbaijan use the moisture index Md [8] expressed in the form of annual atmospheric precipitation/sums of daily mean moisture deficit ratio for the same period as a moisture factor.

Expected changes

According to calculations, the sum of active air temperatures >10°C in the territory of the republic increases depending on regional specifics according to the scenarios involved as follows: 1000-1250° *(GISS),* 1000-1500° *(GFDL-3)* and 300-850°*(exp.)*. According to the *PRECİS 1.4* scenario it may increase by 100-700^0 /**I**/ and 1100-1500^0/**II**/. Duration of a period with daily mean air temperature above 10°C may accordingly increase by 20-40, 30-50 and 3-30 days. According to the *PRECİS 1.4* scenario may accordingly increase by 10-35 and 25-80 days, and thermal zone boundaries in mountains will shift 550-850 m (*GISS*), 720-950 m *(GFDL-3)* and 230-460 m upward *(exp.).* According to the *PRECİS 1.4* scenario, zone boundaries may shift 150-380 m upward in the first period and 430-930 m upward in the second one (Table 2).

Thus, increase in thermal resources, expansion of the area of thermal and temperate zones and decrease of the frigid and thermal zones areas.

Table 2. Value of possible shift of thermal zones, m

Greater Caucasus		Lesser Caucasus		Talysh	Nakhchivan AR
Southern slope	North-eastern slope	Northern slope	Eastern slope		
GISS					
650	800	750	550	850	550
GFDL-3					
720	870	950	720	950	720
Expert					
390	460	460	260	230	290
PRECIS 1.4 /I/					
340	380	350	200	150	250
PRECIS 1.4/II/					
770	950	850	750	1080	1100

Moisture resources. According to the *GISS* model, increase in annual atmospheric precipitation by 6-12% is expected in the territory of the republic. Realization of the *GFDL-3* model supposes a change in the annual precipitation from -5 to +4%. In case of the *PRECİS 1.4 /**I**/* scenario about 20% increase may be expected in atmospheric precipitation, and in case of the *PRECİS 1.4 /**II**/* scenario decrease of atmospheric precipitation by 10-20% may be expected in the territory of the Nakhchivan AR and by 20-40% in the remaining territory of the country.

According to calculations, realization of the *GISS* scenario may lead to increase of evaporability by 35% on average that will make in absolute values 180-540 mm per year, 120-470 mm for the thermal period and 20-290 mm for summer. If the *GFDL-**3*** scenario is realized, evaporability values will be much the same as in the *GISS* scenario. In case of the expert scenario evaporability values may increase by 15% on average that will make in absolute values 70-220 mm per year, 50-190 mm for the thermal period and 20-120 mm for summer. In case of the *PRECİS 1.4* scenario greater increase of evaporability as compared with atmospheric precipitation would lead to growth of the moisture deficit which may be 85-260 mm for the first period and 20-100 mm for the second one depending on a region during the vegetative season.

Thus, humid zone boundaries will shift towards mountains due to much greater increase in evaporability as compared with increase in atmospheric precipitation. Such shift will be less prominent than thermal zone shift and make from 50 to 400 m depending on a scenario and region though.

Agriculture

Winter wheat. In the result of climate change, reduction of the vegetation period by 10-40 days may be expected in traditional grain-growing regions. It will become possible to extend winter wheat to the height of 1600-1800 m above sea. However, the planting acreage will not extend considerably due to scarcity of land resources. As at present time in future, cropping will be mainly carried out on irrigated fields. That's why the field productivity will considerably depend on irrigation water supply. If the *GISS* scenario is realized, yield depression by 3-4% on average may be observed in the rainfed zone, and in case of the *GFDL*-3 scenario a 7-9% yield gain may take place.

Grape. Rise in temperature during the thermal period in all climate change scenarios will make it possible to extend the vine-growing area to the middle altitude, and rise in temperature during the winter season will provide its cultivation on the field.

It is expected that the productivity of bogharic vineyards would decrease by 10% on average in the result of climate change according to the GFDL-3 scenario and by 5% on average according to the GISS scenario. Realization of the PRECIS 1.4 /I/ and PRECIS 1.4 /II/ scenarios is expected to lead to 4-5% and 10% yield gain respectively. The grape juice quality will be favoured with climatic conditions of the grape ripening stage: sugar content may increase by 5% on average while juice acidity may decrease by 1% (GISS and GFDL-3). Realization of the expert scenario wouldn't result in such considerable changes, so they would be +3 and -0.5%, respectively. According to the PRECIS 1.4 scenarios, juice sugar content is expected to decrease by 2-3 /I/ and 6-7% /II/ and acidity is expected to decrease by about 1%.

Population health

The observable climate change may impact on health and vital activity of people both with warming and increase of frequency of dangerous hydrometeorological events (floods, mud flow, hurricanes, etc.). This article deals with a possible impact of severe hot weather on human general state and climatic conditions of spread of malaria at the *PRECIS 1.4* scenario, if realized.

Severe hot weather and population health. The severest harm to the human health is caused by heat in metropolises. It is identified [4] that due to increase in the mean air temperature by 1.5^0 C for the thermal period (April-September) in 2003-2007 total number of health care encounters increased by 21.6% in Baku as compared with prior years. At the same time the number of health care encounters due to cardiovascular diseases increased by 34.1%, respiratory diseases – by 22.8% and nervous diseases – by 19.9%. The total number of excessive fatal outcomes increased to a lesser extent (3.4%) as compared with the capitals of some European countries that was associated with the city population adaptability to hot summer. However this index was higher for certain diseases: 26.3% for myocardial infarction and 55.6% for cerebral accidents.

It may be assumed that the number of diseases and excessive fatal outcomes would be almost the same as the above mentioned indices in case of realization of the *PRECIS 1.4* /I/ (2021-2050) scenarios. During the second period (2071-2100), increase in the number of diseases and fatal outcomes (myocardial infarction, cerebral accidents, etc.) may be expected. Increase in the number of elderly people who fall within the so-called 'risk group' and presence of 'heat islands' in cities may aggravate the negative impact of extremely hot weather.

Malaria. The Republic of Azerbaijan is classified as a country with the natural nidus of malaria. Currently there are only residual niduses of tertian malaria (*P.vivax*) in the country and malariagenic situation may be considered stable. The zone of **endemic** malaria stretches from the Caspian sea cost to the height of 1000-1200 m above sea, and from the Aras River bank to the height of 1500-1700 to 2000 m above sea in the Nakhchivan AR. A m**alaria-free** zone is located in the higher territories. In the result of climate warming, both endemic and epidemic zone may extend towards mountains during the first period [5]. Duration of the epidemic season may increase by 5-10 days in the Kura-Aras Lowland, by 10-15 days in the peri-Aras plains of the Nakhchivan AR and by 15-30 days at the height of 500-1200 m above sea.

During the **second period** rise in the air temperature will create conditions for the additional extension of the malariagenic areas and increased duration of the epidemic season. However, taking into account the population density of the territories located at the height more than 1500 m above sea (1.2% of the population of the country) probability of new malaria nidus occurrence at this height is minor.

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