SCENARIO OF CHANGES OF THE VEGETATION PERIOD AND ACTIVE TEMPERATURES IN EASTERN GEORGIA UNDER GLOBAL WARMING

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Abstract. *Forecasts of the duration of the vegetation period (days) and the sum of active temperatures (>10°C) under global warming conditions significantly determine the growth and development of crops and their productivity. For each municipality of the regions of Eastern Georgia, a future scenario of the duration of the vegetation period (days) and the sum of active temperatures (>10°C) has been compiled, with the corresponding forecast regression equations, when the temperature increases by 2°C (2020-2049). With the above equations, the duration of the vegetation period and active temperatures for the future are determined by the municipalities.*

Key Words: *vegetation period, active temperature, crops, forecast*

Forecasts of the duration vegetation period and the sum of active temperatures (>10°C) are important for agricultural workers, farmers, and those employed in the private agricultural sector. For example, if this year, the forecasted sum of active temperatures, under optimal conditions of other factors (atmospheric precipitation, air humidity, etc.), will be higher than the sum of the average active temperatures of a given territory (by 300-400°C), we should assume that the growth and development of crops and their productivity will be ensured, and vice versa, i.e. the harvest and its quality will be lower by 20-30% or more. Also, a duration vegetation period is favorable for normal plant growth and development and high productivity, and vice versa. Therefore, in connection with global climate change, a climate change scenario has been developed for Georgia. In particular, the regional RegCM-4 and the socio-economic development future scenario A_1B_1 (temperature increase by 2°C, 2020-2049) have been used to forecast local climate change [1]. This model calculates meteorological observation data (in this case, daily average air temperatures) for the forecast period of 2020-2049. From the future forecast climate parameters, the average temperatures of each year from the meteorological observations of the National Environmental Agency have been used, and the dates of the transition of temperatures above 10°C in spring and below 10°C in autumn have been determined. Which is calculated by the following equations:

$$y = -2.4x + 79 \text{ (in spring)},$$
$$y = 3.2x - 33 \text{ (in autumn)}$$

In the equations, y is the dates of the temperature transitions up >10°C and down <10°C in spring and autumn; x – the sum of the average temperatures of two months in spring and autumn, or each month (February-March or March-April in spring, September-October or October-November in autumn), the average temperature of the first month must be less than 10°C, the second month – more than 10°C [2, 3].

The sums of active temperatures (>10°C) during the vegetation period were calculated between the received dates. The duration of the vegetation period (days) was also calculated. High correlations were identified from the mentioned characteristics. Specifically, during the vegetation period in spring, the earlier the date of the average daily air temperature exceeding >10°C is observed, the greater the sum of active temperatures accumulates, and vice versa. The duration of the vegetation period (days) is of a similar nature. In this regard, Acad. Davitaia noted that late spring is a sign of a general heat deficit. Because the low temperature in spring is generally not compensated for by the temperatures in summer and autumn.

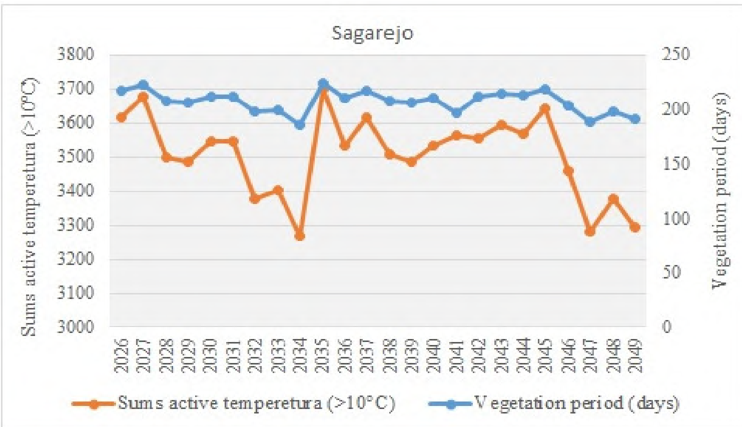
Based on the above-mentioned regularities, we have compiled a future scenario for the duration of the vegetation period (days) and the sum of active temperatures (>10°C) for each municipality of the regions, with a temperature increase of 2°C (2020-2049), with the corresponding forecast regression equations (Table 1).

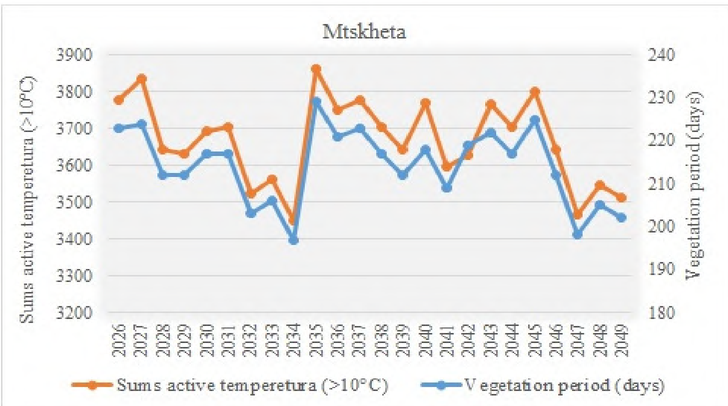
Table 1. Forecast equations for the duration of the vegetation period (days) and the sum of active temperatures (>10°C) (future scenario, with a temperature increase by 2°C, 2020-2049)

Region, Municipality	Regression equation of the vegetation period		
	Regression equation (Σn)	correlation coefficient (r)	admissible error S_u± (day)
Kakheti, Sagarejo	Σn=-0.9624*x+268.16	r=0.86	7
Mtskheta-Mtianeti, Mtskheta	Σn=-0.9429*x+269.77	r=0.93	6
Samtskhe-Javakheti, Akhaltsikhe	Σn=-1.3175*x+286.62	r=0.89	7
Kvemo Kartli, Bolnisi	Σn=-1.0329*x+291.86	r=0.71	10
Shida Kartli, Gori	Σn=-0.9842*x+273.02	r=0.94	5
Municipality	Regression equation of the sum of active temperature (>10°C) (ΣT)		
Sagarejo	ΣT=-11.996*x+4253.14	0.75	193°C
Mtskheta	ΣT=-12.0165*x+4377.13	0.77	131°C
Akhaltsikhe	ΣT= -20.46*x+4900.01	0.75	143°C
Bolnisi	ΣT=-18.387*x+5554.21	0.74	173°C
Gori	ΣT=-12.272*x+4363.03	0.77	122°C

The reliability of the forecast equations given in Table 1 can be assessed by the admissible error of the equation, which, for the forecast of the duration of the vegetation period, depending on the region, ranges from ±5 days to ±10 days, and for the forecast of the sum of active temperatures, from 122°C to 193°C. Forecasts can be made in the spring, in the first pentad of May, in the mountainous zone (Sagarejo, Akhaltsikhe), and in the first pentad of June. When we have information on the temperatures of the two months preceding the mentioned months from the meteorological stations of the respective municipalities of the region. The forecast advance is quite long and amounts to 5-6 months [4].

Fig.1 shows the projections for the duration vegetation period (days) and the sum of active temperatures (>10°C) for the municipality of eastern Georgia regions under a 2°C temperature increase (future scenario, 2026-2049).





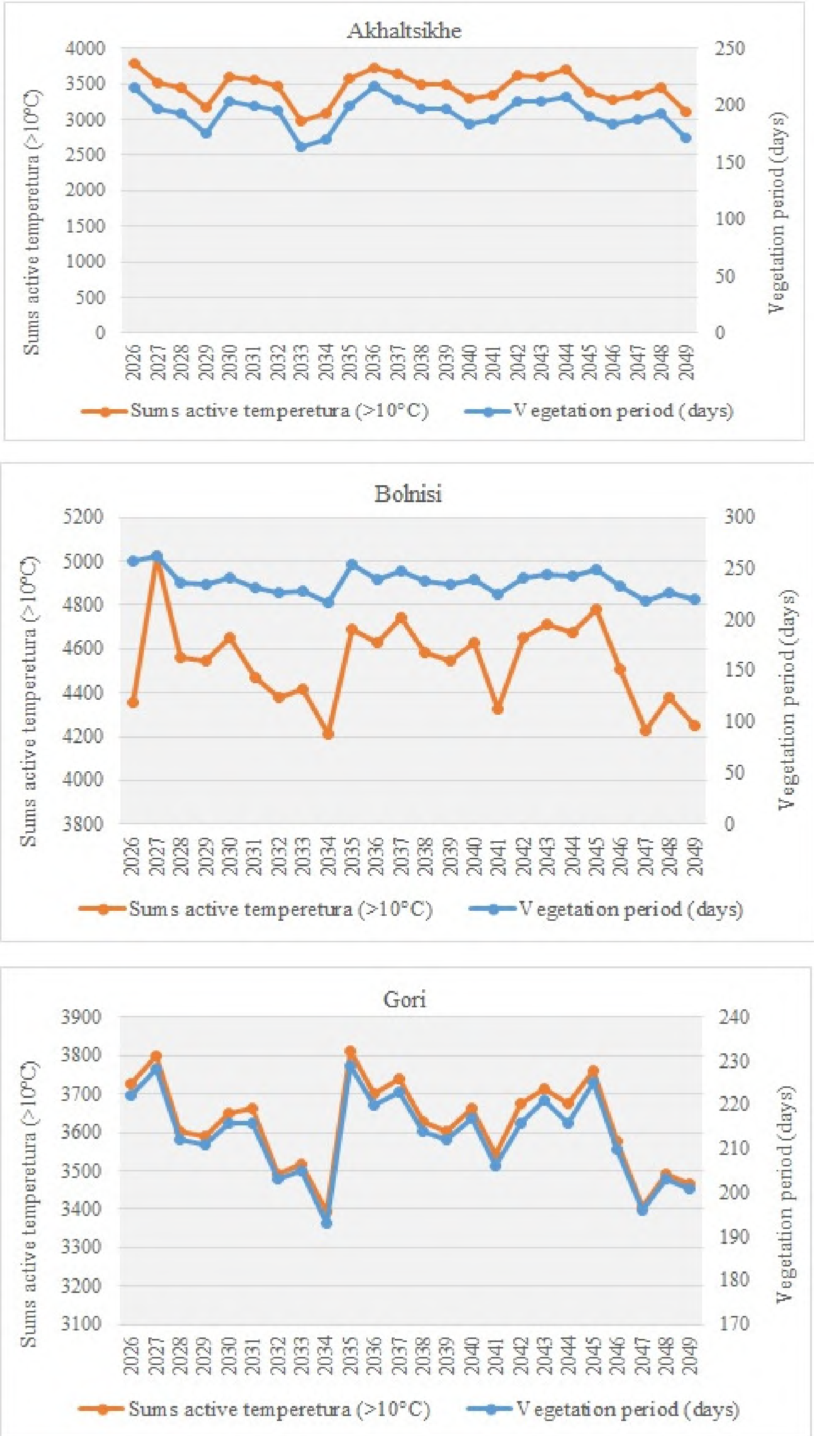


Fig. 1. The duration vegetation period (days) and the sum of active temperatures (>10°C) for the municipality of eastern Georgia regions under a 2°C temperature increase (future scenario, 2026-2049).

According to the analysis of Figure 1, the forecasts of the duration of the vegetation period by region and the sum of active temperatures (>10°C) for the entire vegetation period are noteworthy and should be taken into account. In this regard, we note that according to the forecasts made in the regions under the scenario, when the temperature increases by 2°C, the sum of active temperatures is high everywhere. Therefore, for the normal productivity of plants, it is necessary to carry out irrigation measures for crops, especially during the June-August vegetation period.

According to Figure 1, based on local climatic conditions, the Kvemo Kartli region (Bolnisi, Gardabani, Marneuli) is characterized by the highest increase in the sum of active temperatures. However, this increase in temperature will not hinder the normal development of crops if the temperature does not increase more than that envisaged by the scenario.

It is not difficult to make a forecast for the future. Agricultural workers, specialists, farmers, and those interested in drawing up a forecast for the regions for 2026-2049 can determine the dates of the temperature exceeding 10°C. To do this, data are needed to determine the date of the average temperature exceeding 10°C in the spring, in March-April. For example, let's assume that the average temperatures for March and April for the Gori municipality of the Shida Kartli region in 2026 are determined by the following equation:

$$y = -2.4*x + 79$$

The date of the temperature exceeding 10°C will be 24.III, or 1 – the number of days counted from February is – 52. By inserting the latter instead of n in the corresponding equation for the region ($\Sigma T=12.272*n+4363.03$) and performing mathematical operations, the forecast of the active temperature sum for the current year (2026) will be 3725°C. Similarly, the duration of the vegetation period for the given region from the same date is determined by the corresponding equation, where 222 days are obtained.

Based on the analysis of the above-mentioned studies, global warming during the vegetation period affects the agroclimatic characteristics of the study area. In particular, the growing season is extended, the sum of active temperatures is also increased (>10°C), and atmospheric precipitation is mainly reduced. According to these characteristics, hydrothermal coefficients are reduced, which is an indicator of the frequency and recurrence of various types of droughts. Therefore, it is necessary to develop mitigation measures in this regard. In dry subtropical and slightly elevated mountainous zones, the production of selected perennial and annual crops that are resistant to relatively high temperatures and drought resistance should be especially considered. In mountain and highland zones, it is recommended to arrange terraces on steep slopes (10° and more), which significantly reduces water runoff and intensive evaporation of water from the soil. Cultivation-loosening of the soil surface is effective, as well as the cultivation of windbreaks of plants against the prevailing winds, which creates a favorable microclimate for crops. In addition, in connection with modern climate change, varieties resistant to diseases and pests should be bred for wheat production. It is also important to widely introduce and use irrigation water by sprinkling and drip irrigation methods. Given the current global climate change, it is necessary to consider the practical use of agrometeorological forecasting methods for the occurrence of harvest and phenological phases in the scenario of a 2°C increase in temperature. It is also necessary to raise public awareness in terms of vulnerability assessment, adaptation, and the development of mitigation measures.

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