PROJECT

Transboundary water management adaptation in the Amudarya basin to climate change uncertainties

Report

2.3. Modeling crop water requirements in context of climate change

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Tashkent 2016

1. Research objective and tasks

Research objective: analyzing and assessing a positive effect of climate change through shortening of plant growth and development phases.

Research tasks and their fulfillment:

1. Analyze change of bioclimatic potential for all planning zones within a year. The year 2000 was chosen as a base year.
2. Calculations were based on the sum of effective temperatures > 5 ^{0}C, > 10 ^{0}C and > 15 ^{0}C per year.
3. Graphs of the sums of effective temperature were plotted for 2000-2050.
4. Materials on climate change were prepared: transition through temperature threshold > 5 ^{0}C, > 10 ^{0}C and > 15 ^{0}C - input data for determining sowing dates of crops.
5. Graphs of change in the dates of spring temperature transition >5 ^{0}C, > 10 ^{0}C and > 15 ^{0}C were plotted.
6. Materials on the sums of effective temperatures were collected for development and growth phases of crops grown in the basin and then analyzed.
7. Based on the sums of effective temperatures t^o, the sums of effective temperatures t^o for development phases and changes in duration of development phases were calculated and analyzed.
8. Data to be inputted into DB were prepared to calculate water requirements.

2. Research methodology

The findings of the past research on climate change adaptation completed together with the McGill University from Canada [1] were used as a working assumption. It was found that a cumulative increase of temperature potential should result in shortening of the growing season of crops. Similar results were published by us together with V.Usmanov [2] earlier. However, those only referred to changes in dates of transition through the threshold values of plant growth and development - 5, 10, and 15°C, respectively for various crops. During further research under the project “Central Asian Water” (CAWA) financed by the Federal German Foreign Office, it was decided to study an effect the changes in duration of growth phases of various plants and speeded up development of plants would have on crop water requirements, specifically on reduction of required irrigation days. This work also took into account high temperatures that slow down development of plants until full cessation of cell growth. Such threshold temperature, for example, for cotton is 35 °C. Achieved research results for the Fergana Valley under the CAWA project showed [3,4] that the rise of thermal potential allows accumulating the sum of effective temperatures in a shorter time and occurring earlier sowing dates. Firstly, this will allow shortening the crop development and growth phases and the growing season of a crop in general. Consequently this will decrease water requirements by more than 100 mm for cotton, the main crop. Distribution of thermal resources should be considered as the basis for crop rotation and water-use plan. Taking into account the positive results achieved earlier, it was decided to use this experience in the analysis of bioclimatic potential and its change in the Amudarya basin.

The Wurzburg University’s REMO model was used for forecasts of climate change. This climatic model is based on the ECHAM 5 model developed at the Max Plank Institute (Germany). That is the model of global atmosphere circulation. It is used for calculation of global and regional models of climate change. The A1B scenario of average warming as a result of greenhouse gas emission was played in the model. Given model allowed constructing the artificial temperature and rainfall series until 2050. The modeling results were calibrated (G.F.Solodkiy).

The REMO modeling data were provided for the whole Amudarya River basin. Water requirements will be modeled using the REQWAT model developed on the basis[1] of the CROPWAT model. REQWAT is used for calculation of water requirements for a specific area. A planning zone map, an irrigated area map, the radar survey data, a soil map, a groundwater well location map and the observations on groundwater levels for a series of years were used in those calculations. The results are displayed in form of ten-day or monthly crop water requirements averaged for the studied area or as maps of annual crop water requirements.

3. Research results

3.1. Assessment of thermal resources and their forecast

The following thermal zones were singled out in Central Asia [5].

I. Hot zone – the sum of temperatures above 10^{o}C is more than 4000^o C (thermal resources are enough for growth and good ripening of cotton)

II. Warm zone - the sum of temperatures above 10^{o}C ranges from 2800^{o}C to 4000^{o}C (heat is not enough for good bearing of cotton but is sufficient for grapes, including early varieties).

III. Cool zone - the sum of temperatures varies from 1000^{o}C to 2800^{o}C (thermal resources are not enough for ripening of grapes but are sufficient for growth of spiked cereals).

IV. Cold area - the sum of temperatures is less than 1000^{o}C (non-agricultural area).

The rate of crop development is closely linked to the effective temperature. The effective temperature is the difference between the mean daily temperature and the temperature at which development of any crop starts - lower limit of effective temperatures. The sum of the mean daily temperatures that are higher than the lower limit of temperature for one or another period (from sowing to sprouting, from sprouting to formation of 1st leaf, for growing season) is the sum of effective temperatures. The lower limit of temperature varies depending on crop. For example, it is 5^{o}C for cereals and most fruits, 10^{o}C for cotton and 15 ^{o}C for heat-loving plants.

At the same daily air temperature, effective temperatures for crops having different temperature limits for start of their growth will vary.

For the analysis, more significant and universal temperature limits (> 5 ^{0}C, > 10 ^{0}C and > 15 ^{0}C) were chosen to assess bioclimatic potential.

The analysis of data shows that the annual sum of effective temperatures> 5 ^{0}C, > 10 ^{0}C and > 15^{0}C generally will increase by 2050 in all planning zones. The trends of the sums of effective temperatures were determined (Table 3.1) based on the coefficient of linear function. Approximation of linear function relationships showed that the closer the inclination of line to axis Y, the higher the rate of change in parameters. The analysis results (Table 3.1) reveal that the accumulation rate of effective temperatures is highest in the mountainous areas.

[1] Q

Table 3.1

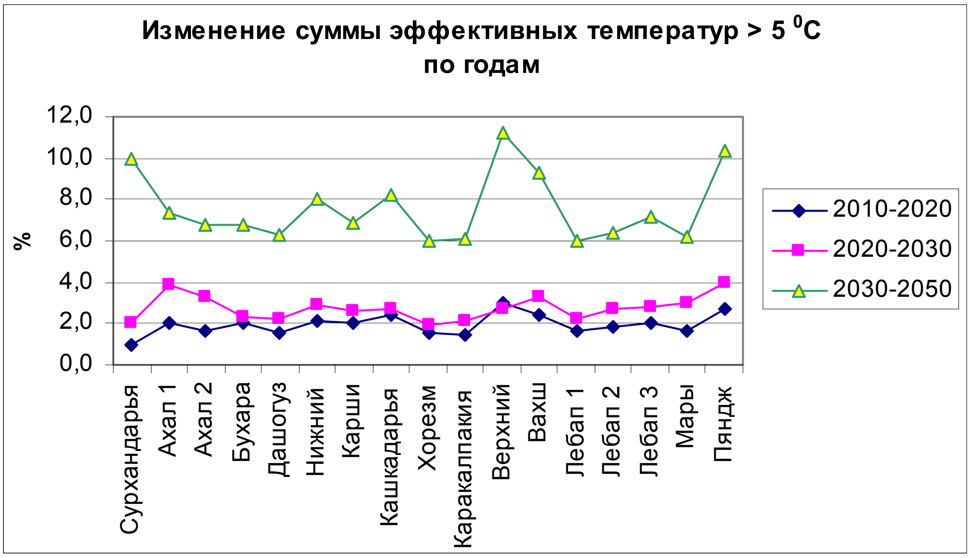
Trends of the sums of effective temperatures

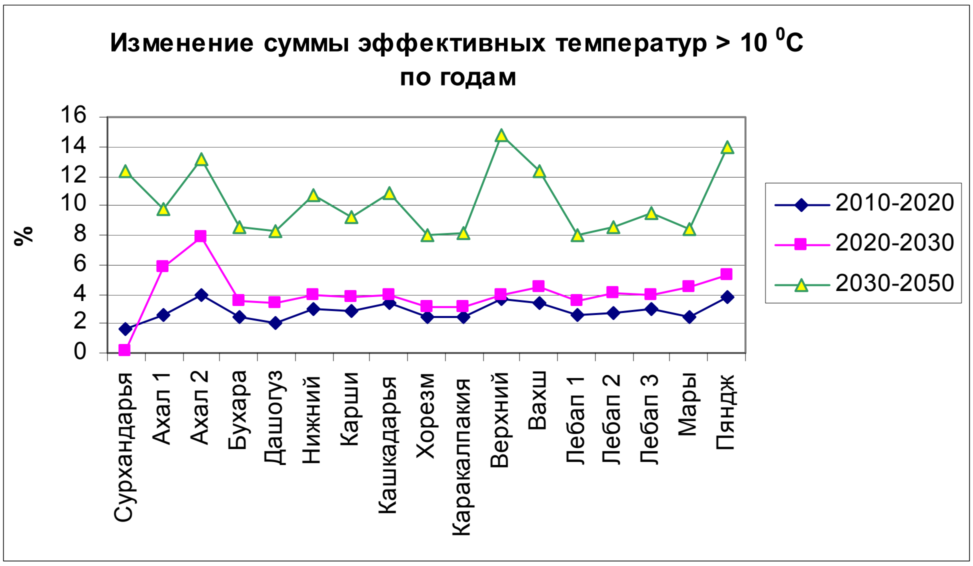
	> 5 ^{0}C	> 10 ^{0}C	> 15 ^{0}C
Upper Karnifigan	9.92	8.89	8.15
Pyandj	9.18	8.17	7.25
Akhal 1	8.48	7.73	6.83
Surkhandarya	8.44	7.37	6.63
Vakhsh	8.22	7.27	6.47
Akhal 2	7.96	7.25	6.13
Bukhara	8.06	6.99	6.41
Kashkadarya	7.28	6.41	5.67
Lower Karnifigan	7.09	6.29	5.61
Dashoguz	7.06	6.29	5.38
Lebap 3	6.38	5.68	5.08
Karshi	6.19	5.49	4.91
Mary	5.82	5.26	4.75
Lebap 2	5.78	5.18	4.63
Karakalpakstan	5.67	5.04	4.4
Lebap 1	5.57	4.97	4.34
Khorezm	5.54	4.95	4.30

The sum of effective temperatures > 5 ^{0}C varies within 4300-2600 ^{0}C in the Amudarya basin; > 10 ^{0}C within 3100-1600 ^{0}C; and, > 15 ^{0}C within 2000-900 ^{0}C (**APPENDIX 1**, Figures 1-17). According to the classification [5], this territory refers to warm zone and to northern boundary of cotton growing.

Comparison of the sums of effective temperatures in 2010-2020, 2020-2030 and 2030-2050 clearly showed (Fig.3.1.) an increase in these sums by 2030-2050 in all planning zones. 2000-2010 were considered as base years.

The use of bioclimatic resource in the future may be more optimal in formation of cropping pattern, selection of crop varieties and change of agronomic practices. Eventually, this should change water use planning.





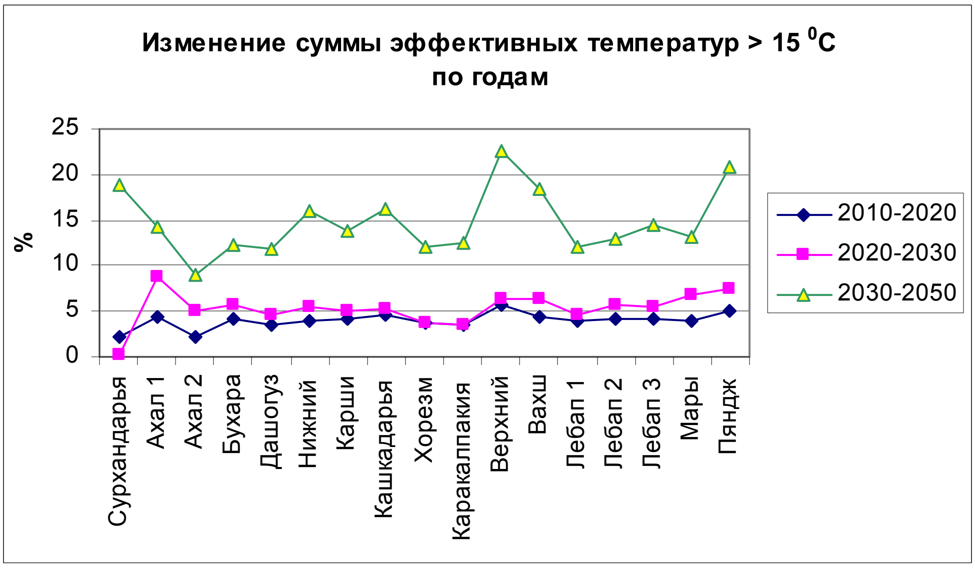


Fig.3.1. Changes in the sums of effective temperatures by year

3.2. Changes in the date of steady temperature transition

The date of steady spring temperature determines the main parameters, such as the beginning of growing season and sowing dates.

In the Amudarya River basin, the steady transition of air temperature through 0^{o}C, corresponding to the beginning of growth of early fruits (apricot, almond), is observed in the 2nd ten-days of February in Bukhara planning zone. Autumn transition through 0^{o}C is observed in 2nd and 3rd ten-days of December. The duration of the period, when the air temperature is above 0^{o}C is 280-310 days and 365 days in frost-free years.

Renewed growth of alfalfa, cereals and most fruits and spring growth of pasture grasses start when air temperature passes 5 ^{0}C. This transition occurs (**APPENDIX 2**, Fig.18-34) firstly in plain area of the basin in Bukhara planning zone at the end of February, in Akhal planning zone – in the first ten-days of March, in the rest parts of the basin – in March and in the mountainous areas – from the first ten-days of April. The duration of the period, when the air temperature is above 5^{o}C varies for years and planning zones between 200 and 270 days; when the air temperature is above15 ^{0}C, it varies between 145 and 180 days.

An active growth of most crops coincides with steady transition of air temperature through 10^{o}C. This time we have favorable conditions for sowing of heat-loving crops, such as cotton and maize

Spring transition of air temperature through 10 ^{o}C is firstly observed in Bukhara and Akhal planning zones in the 3rd ten-days of March, while in the rest parts of the basin – in the first ten-days of April. The duration of the period, when the air temperature is above 10 ^{o}C lasts 170-200 days on average and when the air temperature is above 15 ^{0}C – 145-180 days.

Рис.3.2. Изменение годовых значений суммы эффективных температур > 5 ^{0}C к 2050 г, (%)

Fig.3.2. Change in annual values of the sum of effective temperatures > 5 ^{0}C by 2050, (%)

Рис.3.3. Изменение годовых значений суммы эффективных температур > 10 ^{0}C к 2050 г., (%)

Fig.3.3. Change in annual values of the sum of effective temperatures > 10 ^{0}C by 2050, (%)

Рис.3.4. Изменение годовых значений эффективных температур > 15 ^{0}C к 2050 г., (%)

Fig.3.4. Change in annual values of the sum of effective temperatures > 15 ^{0}C by 2050, (%)

Примечание: 2000-2010 г.г. / 2030-2050 г.г.

Рис.3.5. Даты перехода температур > 5 ^{0}C

Fig.3.5. Dates of temperature transition through > 5 ^{0}C

Рис.3.6. Даты перехода температур > 10 ^{0}C

Fig.3.6. Dates of temperature transition through > 10 ^{0}C

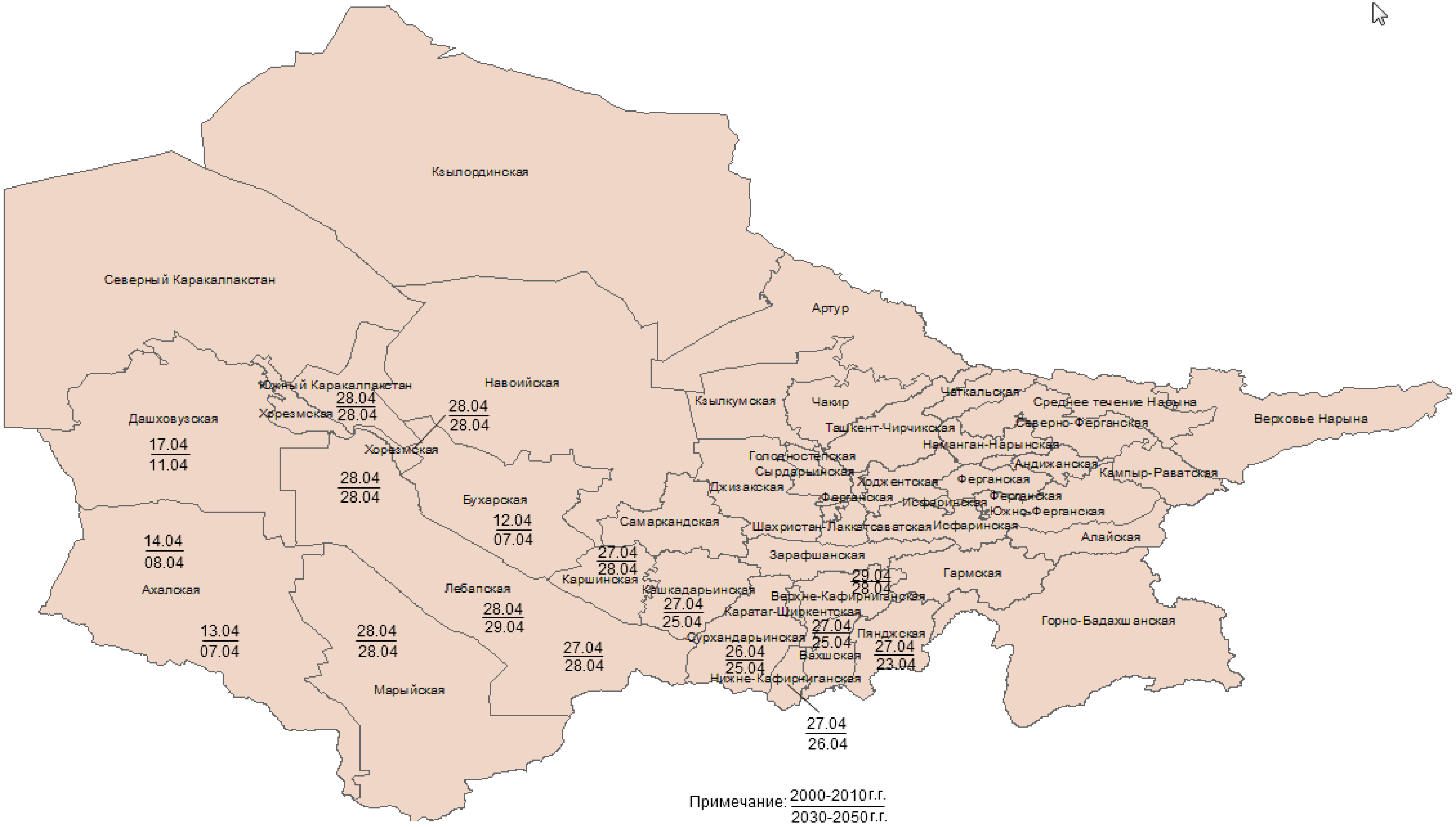


Рис.3.7. Даты перехода температур > 15 ^{0}C

Fig.3.7. Dates of temperature transition through >15 ^{0}C

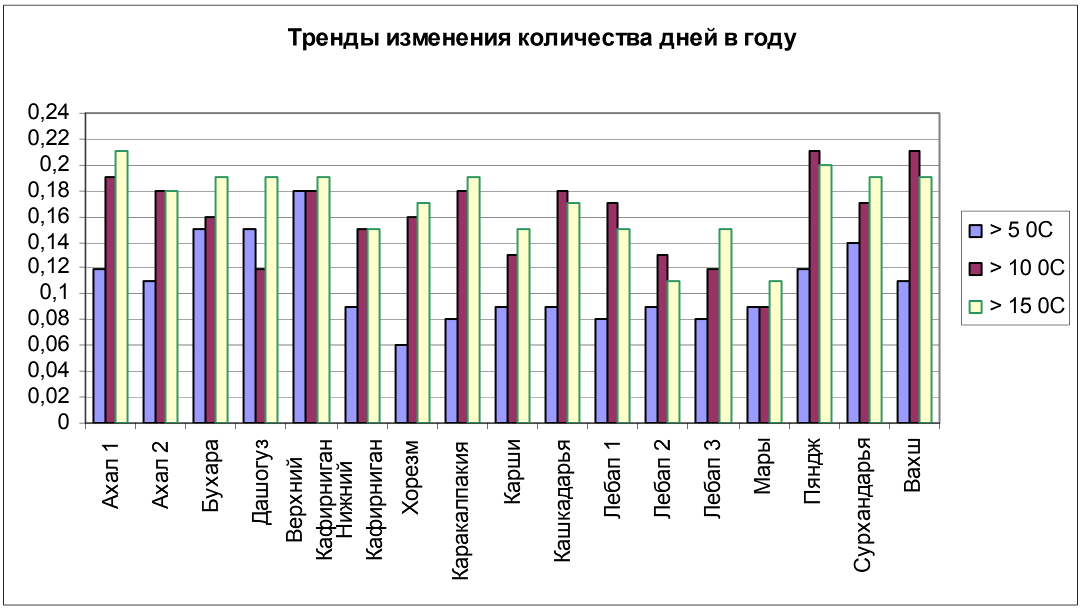


Fig.3.8. Trends of changes in number of days in a year with temperatures > 5 ^{0}C, > 10 ^{0}Cand > 15 ^{0}C

The Figures (**APPENDIX 3**, Figures 36-52) show the changes in steady temperature transition through 5 ^{0}C, 10 ^{0}C and 15 ^{0}C, at which it is recommended to sow many crops, including cotton, maize, rice, many vegetables, etc. (Table 3.2).

Table 3.2

Optimal temperatures for sowing crops

№	Crop	t^0 sowing	№	Crop	t^0 sowing	№	Crop	t^0 sowing
1	Peanut	12.00	13	Melon	15.00	25	Early rice	10.00
2	Legumes	12.00	14	Sweet pepper	10.00	26	Late rice	10.00
3	Table grapes	8.00	15	Sorghum	10.00	27	Orchard	5.00
4	Cabbage	5.00	16	Soya	10.00	28	Bush	5.00
5	Potato	10.00	17	Pumpkin	13.00	29	Legumes as double crops	10.00
6	Maize for grain	10.00	18	Tomato	12.00	30	Potato as double crop	10.00
7	Alfalfa	5.00	19	Water melon	15.00	31	Beet as double crop	10.00
8	Small vegetables	9.00	20	Early cotton	10.00	32	Cucurbits as double crops	10.00
9	Carrot	8.00	21	Mead-season cotton	10.00	33	Vegetables as double crops	10.00
10	Sunflower	8.00	22	Late cotton	10.00	34	Maize for silage as double crop	10.00
11	Winter wheat	5.00	23	Maize for silage	10.00	35	Rice as double crop	10.00
12	Sugar beet	10.00	24	Rice	10.00			

The dates of steady temperature were determined from the actual climatic data of the base period and from the REMO modeling results.

A clear trend of earlier approached date for recommended sowing is observed (Figures 3.5, 3.6 and 3.7). In the REMO scenarios, the deviations from the base scenario of steady temperature transition through 5°C (sowing dates of wheat, alfalfa, cabbage, etc.) are 1 to 8 days closer to winter in planning zones (Fig.3.5).

By 2030-2050, the steady temperature transition through 15°C would be shifted to 0-6 days in spring season, while transition through 15°C would be shifted to 1-6 days.

For all planning zones, early critical temperature transition is forecasted, but Mary and Pyandj planning zones (**APPENDIX 3**, Figures 36-52).

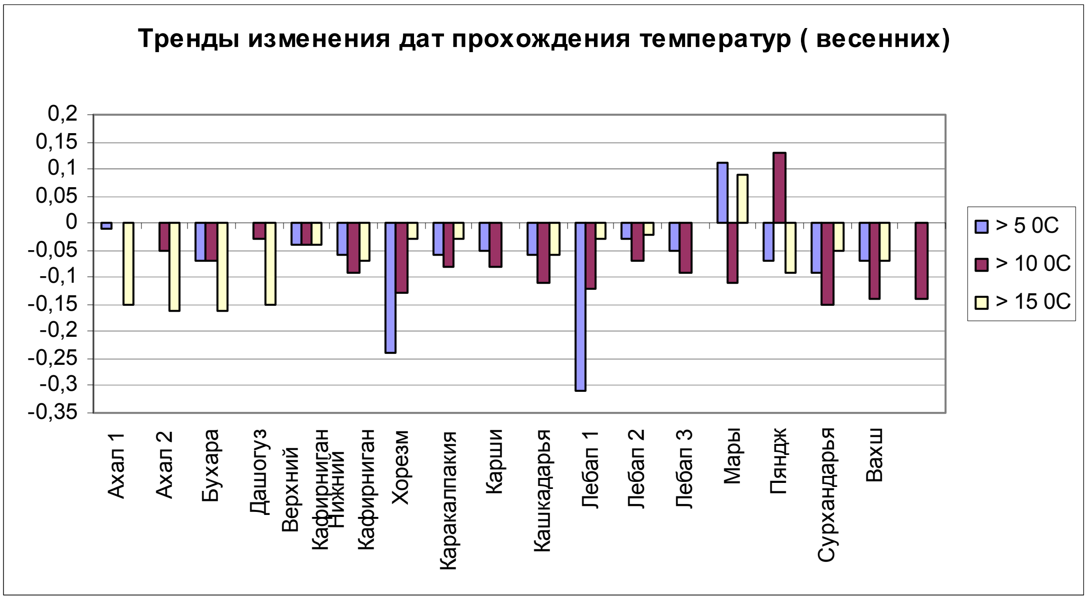


Fig.3.9. Trends of change in the dates of spring critical temperatures transition

The use of trends of change in parameters (Figures 3.8, 3.9) in the analysis allows excluding weight of a year in trends and describes temperature dynamics over longer period more reliably. In this case the observed data are smoothed. The trends of change in parameters indicate to the rate of this change.

The predicted earlier air warming will shift the beginning of the growing season closer to winter.

3.3. Length of crop growing season

Thermal resources are to ensure annual ripening of different crop varieties cultivated in the region.

Climate change, temperature rise will lead to changes in the duration of accumulation of the sum of effective temperatures, which is necessary for ripening of crops.

During each plant development phase, starting with sprouting till blossoming, fruit formation and ripening stage, the plant needs enough quantity of effective temperature as the duration of development phase, the growing season in general and the possibility to control water requirements depend on it.

To calculate the duration of development phases, initial data on main crops of the basin was collected for the base period, including critical temperatures and sums of effective temperatures (Table 3.3), [6, 7, 8, 9, 10, 11].

Table 3.3

Sum of effective temperatures for plant development phases, ^{0}C

№	Crop	Development phase					
		1	2	3	4	5	growing season
1	Peanut	81,17	295,99	621,56	389,07	0	1387,79
2	Legumes	29,48	199,03	463,92	306,29	0	998,72
3	Table grape	134,03	723,47	698,27	916,35	0	2472,12
4	Cabbage	6,01	196,64	268,11	204,29	0	675,05
5	Potato	97,14	279,93	645,36	533,34	0	1555,77
6	Maize for grain	64,43	312,65	562,27	527,26	0	1466,61
7	Alfalfa	350,00	350,00	350,00	350,00	350	2000,00
8	Small vegetables	110,49	246,65	414,51	251,05	0	1022,69
9	Carrot	64,43	370,54	945,89	344,56	0	1725,42
10	Sunflower	37,96	280,83	620,56	441,51	0	1380,86
11	Winter wheat	0,00	0,00	82,95	178,35	0	261,30
12	Sugar beet	134,03	498,38	1467,89	172,71	0	2273,01
13	Melon	95,30	227,80	595,27	335,47	0	1253,84
14	Sweet pepper	134,03	428,93	639,44	353,37	0	1555,77
15	Sorghum	64,43	312,65	645,36	533,34	0	1555,77
16	Soya	64,43	254,36	883,61	439,81	0	1642,21
17	Pumpkin	97,20	295,89	309,68	222,25	0	925,02
18	Tomato	147,59	408,58	755,26	414,38	0	1725,81
19	Water melon	71,03	205,55	322,63	381,53	0	980,75
20	Early cotton	85,00	420,00	450,00	730,00	0	1690,00
21	Mead-season cotton	100,00	460,00	500,00	880,00	0	1940,00
22	Late cotton	100,00	500,00	550,00	1060,00	0	2210,00
23	Maize for silage	97,14	337,83	587,46	17,83	0	1040,26
24	Rice	270,00	620,00	640,00	250,00	0	1780,00
25	Early rice	210,00	480,00	400,00	210,00	0	1300,00
26	Late rice	350,00	770,00	920,00	280,00	0	2320,00
27	Orchard	52,14	250,00	800,00	1500,00	0	2602,00
28	Bush	2709,65	743,64	269,45	441,98	0	4164,71
29	Legumes as double crops	322,70	199,03	463,92	306,29	0	998,72
30	Potato as double crop	97,14	279,93	645,36	533,34	0	1555,77
31	Beet as double crop	134,03	498,38	1467,89	172,71	0	2273,01
32	Cucurbits as double crops	95,30	227,80	595,27	335,47	0	1253,84
33	Vegetables as double crops	147,59	408,58	755,26	414,38	0	1725,81
34	Maize for silage as double crop	97,14	337,83	587,46	0,00	0	1300,00
35	Rice as double crop	1,00	620,00	640,00	250,00	0	1511,00
36	Homestead plots	0,35	0,20	0,16	0,23	0	0,94

It is well-known that plant development and growth directly depend on temperature data. Crop is sown at certain air (soil) temperature which is steady during 3-4 days; there are several development phases from sowing to ripening of crops. The data analysis shows the change in the sowing dates due to climate change. Based on REMO forecast, the sowing dates will come earlier for all crops in all planning zones (Table 3.4, Fig. 3.10-3.17). Thus, in 2050 sowing dates for cotton will start 1-17 days earlier as compared to those in 2000, for rice – 1-12 days, for legumes – 2-13 days and for vegetables (potato) – 1-17 days earlier. The growing season of winter wheat in spring will start 1-15 days earlier (Table 3.4, Figures 3.10-3.17).

Ripening of crops occurs at certain sums of effective temperatures, which are higher than critical temperature threshold (Table 3.2) [6, 7, 8, 9, 10, 11, and 12].

Based on the Table of distribution of the sum of effective temperatures by plant development phase (Table 3.3), the length of phases was determined, i.e. the time required for accumulation of necessary temperature. Climate change will impact the length of temperature accumulation, i.e. it will form the length of the whole growing season and each development phase of a plant.

Based on REMO, the results indicate to shortening of the growing season of almost all crops by 2050 in the basin (Table 3.5, Figures 3.18-3.25), **PPENDIX 4** (Figures 53-290)

The most significant changes in the length of growing season are projected for mead-season cotton – 11-29 days, for early and late cotton – 9-21 and 2-21 days, respectively, for rice – 4-27 days. For other crops the forecast is as follows: for winter wheat – 5-9 days, for maize – 7-11 days, for maize for silage – 3-9 days, for legumes – 2-10 days and for vegetables (potato) – 8-17 days. These changes were derived from formulas of the constructed trends, **APPENDIX 4** (Figures 53-290).

Conclusion

The analysis on expected effect of climate change made for the Amudarya basin showed that one of the major effects is the change in temperature potential in the study area.

These changes reflect on the duration of the growing season. For all crops, but rice as double crop, shortening of the growing season is observed: from sowing dates to harvesting.

Firstly, these forecasts should be taken into account in agricultural practices to plan the sowing dates, dates of agronomic practices and selection of crop varieties.

Secondly, this will change crop water requirements and operation of irrigation network in the future.

The above data were used to forecast water requirements of main crops in the Amudarya basin.

Table 3.4

Sowing dates by crop

	legumes	potato	maize for grain	alfalfa	winter wheat	sweet melon	early cotton	mead-season cotton	late cotton	maize for silage	rice	orchard	Maize for silage as double crop	rice as double crop
Akhal 1	-3,3	-4,5	-4,5	0,2	-0,5	-9,3	-4,5	-4,5	-4,5	-4,5	-9,3	-0,5	-0,1	-0,1
Akhal 2	-7,5	-2,6	-2,6	0,2	-0,8	-6,7	-2,6	-2,6	-2,6	-2,6	-6,7	-0,8	-0,1	-0,1
Bukhara	-2,0	-0,6	-0,6	-1,4	-1,9	-10,9	-0,6	-0,6	-0,6	-0,6	-10,9	-1,9	-0,1	-0,1
Dashoguz	-6,3	-2,3	-2,3	-1,7	-0,8	-6,0	-2,3	-2,3	-2,3	-2,3	-6,0	-0,8	-0,1	-0,1
Upper Karnifigan	-6,9	-4,1	-4,1	-9,1	-4,9	-3,9	-4,1	-4,1	-4,1	-4,1	-3,9	-4,9	-0,1	-0,1
Lower Karnifigan	-6,1	-7,9	-7,9	-7,0	-1,9	-3,2	-7,9	-7,9	-7,9	-7,9	-3,2	-1,9	-0,1	-0,1
Khorezm	-13,3	-15,0	-15,0	-11,2	-6,3	-12,1	-15,0	-15,0	-15,0	-15,0	-12,1	-6,3	-0,1	-0,1
Karakalpakstan	-0,7	-9,5	-9,5	-9,9	-3,1	-0,2	-9,5	-9,5	-9,5	-9,5	-0,2	-3,1	-0,1	-0,1
Karshi	-2,9	-4,9	-4,9	-6,6	-1,1	-6,1	-4,9	-4,9	-4,9	-4,9	-6,1	-1,1	-0,1	-0,1
Kashkadarya	-6,9	-6,9	-6,9	-5,0	-3,2	-5,5	-6,9	-6,9	-6,9	-6,9	-5,5	-3,2	-0,1	-0,1
Lebap 1	-10,8	-17,4	-17,4	-16,2	-15,1	-0,6	-17,4	-17,4	-17,4	-17,4	-0,6	-15,1	-0,1	-0,1
Lebap 2	-3,6	-6,2	-6,2	-4,1	-0,9	-2,9	-6,2	-6,2	-6,2	-6,2	-2,9	-0,9	-0,1	-0,1
Lebap 3	-6,3	-4,6	-4,6	-6,3	-1,3	-3,4	-4,6	-4,6	-4,6	-4,6	-3,4	-1,3	-0,1	-0,1
Mary	-3,9	-5,0	-5,0	-2,3	-1,0	-1,8	-5,0	-5,0	-5,0	-5,0	-1,8	-1,0	-0,1	-0,1
Pyandj	-7,8	-10,8	-10,8	-7,0	-2,6	-7,5	-10,8	-10,8	-10,8	-10,8	-7,5	-2,6	-0,1	-0,1
Surkhandarya	-5,2	-5,5	-5,5	-8,4	-3,8	-4,6	-5,5	-5,5	-5,5	-5,5	-4,6	-3,8	-0,1	-0,1
Vakhsh	-7,5	-10,5	-10,5	-7,2	-2,5	-5,7	-10,5	-10,5	-10,5	-10,5	-5,7	-2,5	-0,1	-0,1

Table 3.5

Shortening of the growing season by crop

	legumes	potato	maize for grain	alfalfa	winter wheat	sweet melon	early cotton	mead-season cotton	late cotton	maize for silage	rice	orchard	Maize for silage as double crop	rice as double crop
Akhal 1	-5,6	-8,1	-7,2	-10,1	-7,4	-15,4	-9,3	-13,5	-21,3	-4,8	-8,5	9,9	-6,8	6,8
Akhal 2	-3,7	-8,1	-7,2	-9,6	-8,1	-16,0	-9,4	-13,1	-18,5	-4,7	-8,1	9,3	-6,4	6,4
Bukhara	-6,5	-7,6	-7,5	-7,6	-5,6	-8,2	-9,3	-11,3	-15,4	-5,9	-3,9	8,3	-5,4	7,7
Dashoguz	-2,2	-8,4	-7,4	-9,6	-6,9	-13,4	-9,3	-12,0	-20,9	-4,6	-7,5	6,2	-6,0	4,1
Upper Karnifigan	-10,5	-17,8	-15,1	-12,1	-4,9	-30,2	-21,5	-35,4	-18,2	-8,9	-26,7	9,1	-12,7	5,4
Lower Karnifigan	-7,2	-8,9	-7,5	-8,3	-5,8	-21,5	-11,8	-25,4	-7,4	-2,7	-20,5	7,7	-8,7	1,5
Khorezm	-6,7	-8,7	-7,2	-6,0	-5,1	-10,7	-11,1	-25,4	2,8	-3,5	-14,0	8,1	-6,8	3,1
Karakalpakstan	-8,2	-8,1	-6,4	-6,1	-5,3	-11,9	-10,4	-24,7	5,2	-3,1	-19,8	9,1	-6,7	4,2
Karshi	-7,8	-9,5	-8,1	-7,1	-5,5	-14,2	-12,2	-26,4	-2,6	-3,7	-17,4	6,7	-8,1	2,1
Kashkadarya	-7,2	-10,3	-8,6	-9,5	-4,9	-20,2	-12,3	-27,0	-7,6	-3,9	-19,2	9,1	-9,2	3,1
Lebap 1	-6,2	-7,7	-6,1	-6,2	-3,8	-14,1	-10,5	-25,7	2,5	-2,6	-18,1	8,2	-7,3	3,0
Lebap 2	-7,1	-8,5	-7,2	-7,5	-5,2	-13,9	-11,1	-26,3	2,6	-3,0	-18,8	6,2	-7,9	2,6
Lebap 3	-6,7	-10,3	-9,3	-7,4	-5,4	-16,2	-12,6	-27,9	-2,8	-4,5	-20,4	6,3	-8,1	2,0
Mary	-6,8	-9,6	-8,5	-8,7	-4,3	-14,7	-12,7	-28,0	0,6	-3,8	-20,2	5,1	-8,0	2,0
Pyandj	-8,1	-11,2	-9,0	-10,9	-6,9	-25,1	-14,0	-28,8	-12,4	-3,2	-21,9	10,5	-11,4	3,1
Surkhandarya	-9,8	-12,5	-10,9	-9,1	-5,1	-24,9	-15,9	-29,1	-12,3	-5,5	-22,0	8,7	-10,5	2,9
Vakhsh	-7,7	-8,8	-7,2	-9,6	-6,3	-23,5	-12,4	-25,4	-8,6	-1,9	-22,4	10,8	-10,4	2,7

Рис.3.10. Сдвиг даты сева (хлопок ранний)

Fig.3.10. Shift of sowing dates (early cotton)

Рис.3.11. Сдвиг даты сева (хлопок средний)

Fig.3.11. Shift of sowing dates (mead-season cotton)

Рис.3.12. Сдвиг даты сева (хлопок поздний)

Fig.3.12. Shift of sowing dates (late cotton)

Рис.3.13. Сдвиг даты сева (пшеница озимая)

Fig.3.13. Shift of sowing dates (winter wheat)

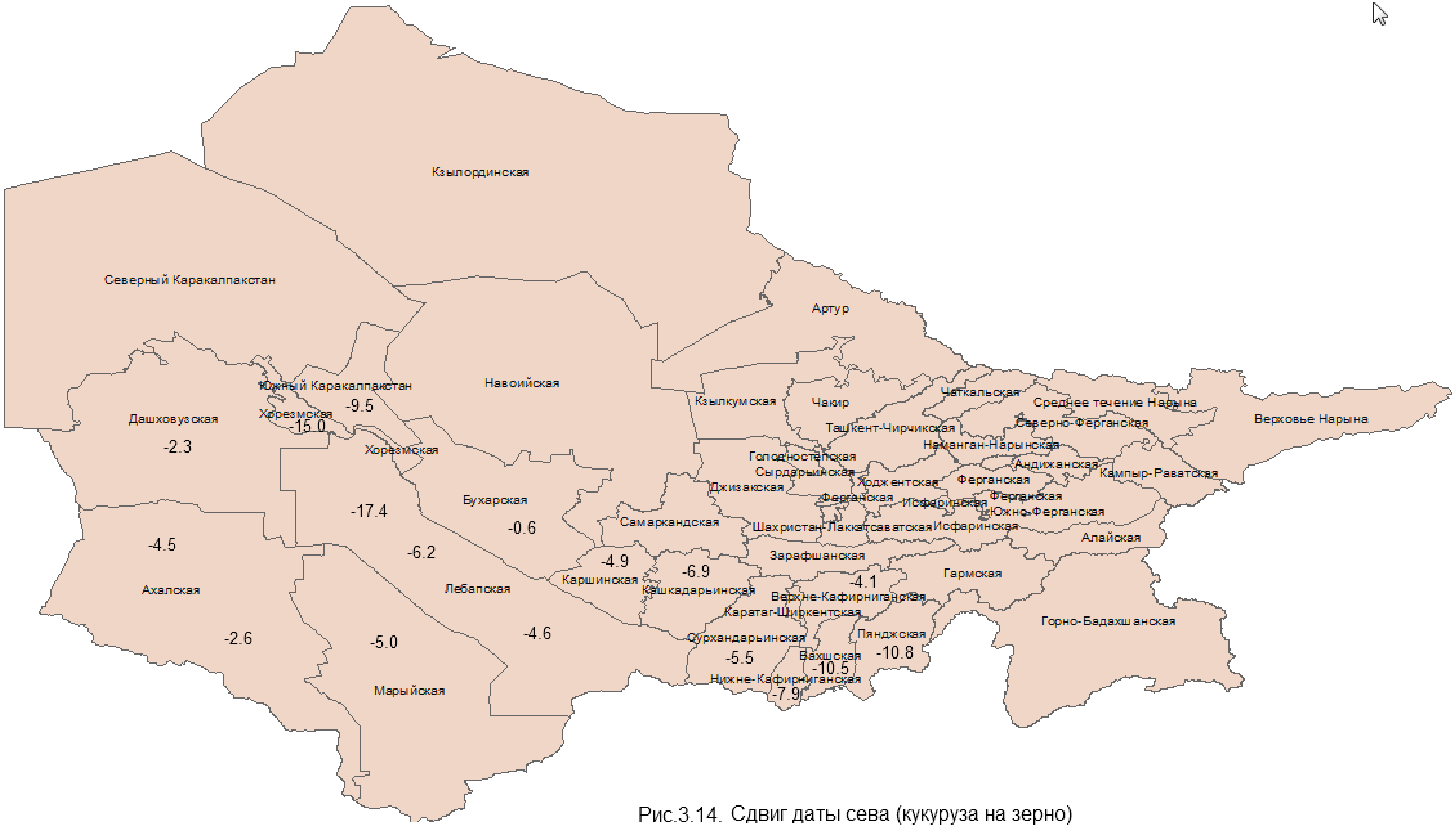


Рис.3.14. Сдвиг даты сева (кукуруза на зерно)

Fig.3.14. Shift of sowing dates (maize for grain)

Рис.3.15. Сдвиг даты сева (картофель)

Fig.3.15. Shift of sowing dates (potato)

Рис.3.16. Сдвиг даты сева (бобовые)

Fig.3.16. Shift of sowing dates (legumes)

Рис.3.17. Сдвиг даты сева (рис)

Fig.3.17. Shift of sowing dates (rice)

Рис.3.18. Сокращение периодов вегетации (хлопок ранний)

Fig.3.18. Shortening of the growing season (early cotton)

Рис.3.19. Сокращение периодов вегетации (хлопок средний)

Fig.3.19. Shortening of the growing season (mead-season cotton)

Рис.3.20.Сокращение периодов вегетации (хлопок поздний)

Fig.3.20. Shortening of the growing season (late cotton)

Рис.3.21. Сокращение периодов вегетации (пшеница озимая)

Fig.3.21. Shortening of the growing season (winter wheat)

Рис.3.22. Сокращение периодов вегетации (кукуруза на зерно)

Fig.3.22. Shortening of the growing season (maize for grain)

Рис.3.23. Сокращение периодов вегетации (картофель)

Fig.3.23. Shortening of the growing season (potato)

Рис.3.24. Сокращение периодов вегетации (бобовые)

Fig.3.24. Shortening of the growing season (legumes)

Рис.3.25. Сокращение периодов вегетации (рис)

Fig.3.25. Shortening of the growing season (rice)

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