Should we think about adaptation to climate change in Central Asia?

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Numerous publications in Europe and now in USA concerning consequences of climate change are somehow ignored by both decision-makers and water leaders.

Perhaps, the reason lies in philosophy of officials who are concerned only with daily issues thus giving less attention to long-term problems.

Seemingly, 1^oC or even 1.5^oC increase in the temperature does not make impression on the lay public. However, the heart of the problem is in consequences of complex processes that take place on the Earth and, particularly, in our region under effect of such temperature change. Undoubtedly, in case of our region, these are problems related to water and its availability, that is ratio between available water resources and water demand.

Until very recently, various forecasts have indicated to minor changes (± 2…4 %) in water resources by 2025…2030. However, for the long-term, i.e. beyond 2030, these figures are more impressive - as much as 10% and even more. Even such figures do not drive anyone for concrete action. And this is despite the fact that some events to which we tried to draw attention of our leaders have already caused certain difficulties and problems in water management. First of all, this concerns one of the most hazardous and complex consequences of climate change - more frequent extreme phenomena, such as floods and droughts.

Let consider hydrographs of our two rivers over last 17 years and compare them with previous 40 years (1990…2007 against 1950…1990, Figures 1 and 2).

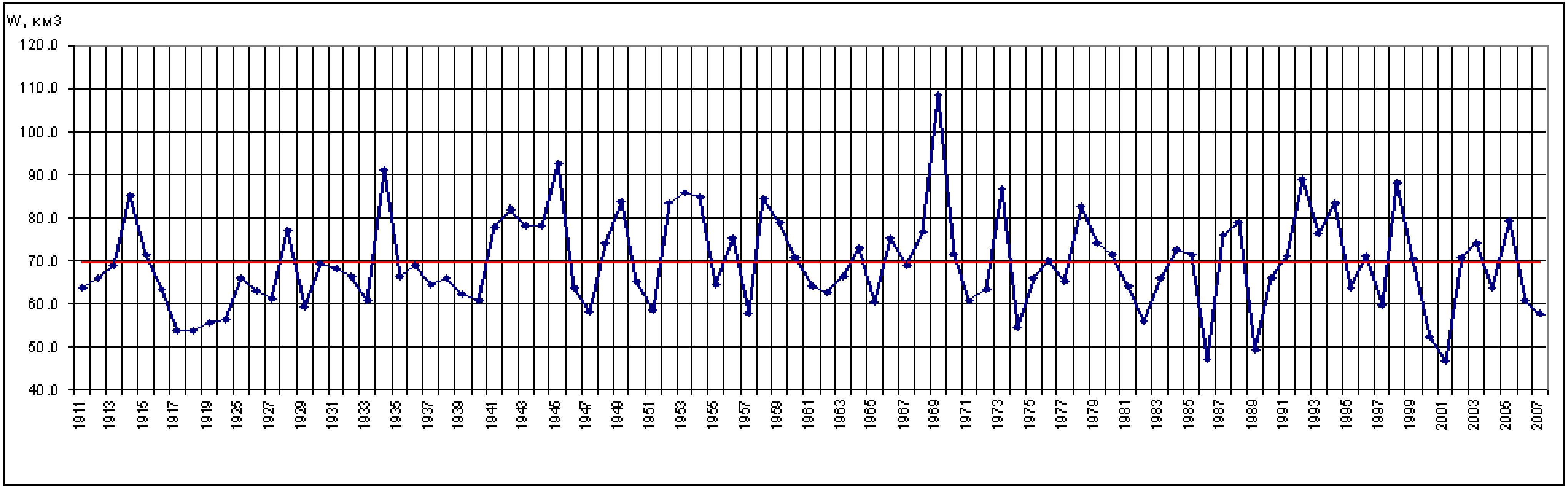

Figure 1. Natural flow of Amudarya river (km^3)

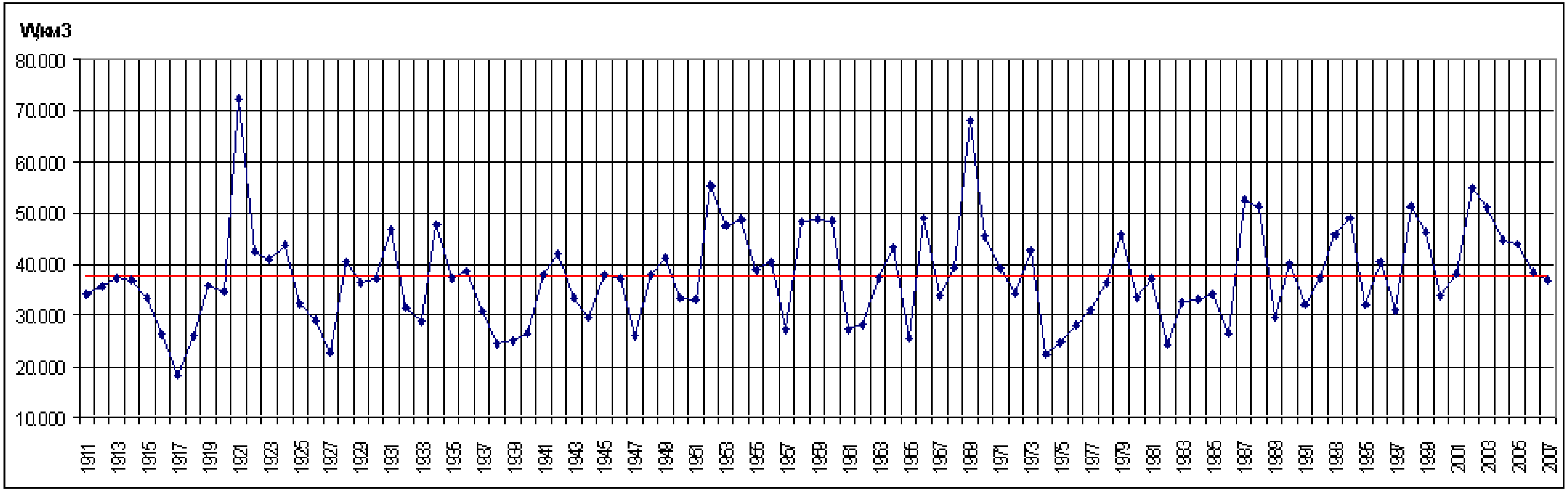

Figure 2. Natural flow of Syrdarya river (km^3)

Run-off of the Syrdarya River and its tributaries over last 17 years averaged 41.6 km^3/year. This is 3.4 km^3 (or 8 %) higher than the mean long-term and annual values over 1950-1990. The same situation is observed for inflows to three upstream reservoirs (Toktogul, Andizhan, Charvak): annual inflow for the last 17 years averaged 24 km^3, that is 1.7 km^3 higher than the mean long-term annual flow over 1950-1990. If we compare mean annual flows in the Syrdarya River over 17 years with the mean long-term flow of 37.6 km^3 over the whole observation period 1911-2007, an increase in flow will be even more (10 %) for 17 years.

Frequency of low-water years in the Syrdarya basin over the 17 years did not become higher as compared to 1950-1990; however, high-water years (25 % probability and lower) became more frequent by 1.4 times, and extremely high-water ones (10 % probability and lower), almost 2 times.

Somewhat different situation is in small Amudarya basin. Run-off of the Amudarya River and its tributaries over last 17 years averages 69.2 km^3. This is 1 km^3 lower (only 1.5 %) than the mean long-term annual value over 1950-1990, but practically similar to the mean long-term flow of 69.3 km^3 over the whole observation period (1911-2007).

Low- and high-water years in the Amudarya basin became more frequent over the last 17 years as compared to 1950-1990. The frequency of low-water years (75 % probability and higher) increased 1.3 times, while that of high-water years (25 % probability and lower) became higher by 1.2 times, and for extremely high-water years (10 % probability and lower), by 2.5 times.

The “depth” of extremely low-water years increased 1.5 times (i.e. deviation of the mean flow in low-water years from that over the period).

Thus, in the recent years, not only floods (for all the rivers) and low-water periods (for Amudarya) became more frequent but the amplitude of deviation from the mean values has increased as well.

Our estimations of resource and consumption fluctuations in the Chirchik-Akhangaran-Keles basin for future scenarios for 25 years show interesting plausible figures: water resources for short-term scenarios may differ by ± 40 from the basic year 2005

Table 1

	Resources		Simulated withdrawal for irrigation	
	ECHAM	HADCM2	ECHAM	HADCM2
Basic year 2003	9213		4380	
min	5131	5440	4225	4210
max	12552	12775	6285	6270
Mean for 2003-2030	8107	8403	5360	5190

We can see an interesting picture: the magnitude of fluctuations is so large that the regulation by Charvak reservoir cannot lessen the flood load, and vice versa, capacities of the reservoir cannot compensate deficit in extremely low-water year even for irrigation, not to mention environmental needs and particularly hydropower and water-supply.

Moreover, such situation would arise in most favorable and, as hold earlier, water-abundant basin.

However, a certain trend should heighten attention of water-management and governmental agencies – water consumption will increase 15-20 % by 2030 in all scenarios!!!

The European Convention's Commission on Climate and Water at their meeting in Bonn opened more frightening figures on the Amudarya basin: the expected decrease of water resources due to diminishing glaciers and glacier component could be 30 %!!!

Hence, adapting to climate change becomes a real and quite critical challenge for Central Asia.

What should be done in order to avoid catastrophic situations in our region, which is the most water critical?

1. Public understanding of and insight into impacts of the hydrological consequences of climate change on the natural, society and economy should become a first pledge of an adaptation campaign. It is well-known that Uzglavgidromet (national hydrometeorological organization) prepares the second batch of information about expected climate changes, which will be more pessimistic than the first one. It is advisable that under the Swiss Project of Regional Center of Hydrology all national forecasts be unified and submitted to the National Governments, ICWC, ICSR and the Aral Fund for consideration. It is necessary to launch a campaign

focused on such materials in media, inter-parliamentary commissions and assemblies.

2. As a first response to more frequent extreme hydrological phenomena, we should pay heightened attention to more intensive long-term regulation and to ensuring of guaranteed water storage in reservoirs. Undoubtedly, present reservoirs for long-term regulation, in fact, are limited by Toktogul and, to some extent, by Charvak together with Andizhan. And under such conditions, attention to construction of Roghun and other waterworks facilities should be concentrated as to long-term regulator, rather than a source of electric energy. Our calculations bring out clearly that under long-term operation regime Roghun reservoir does not operate practically at NMOL 1240, and it is important for the region to have reservoir at NMOL 1290, which allows optimal regimes for all players of Amudarya water-management system.

   Kambarata 2, which allows achieving river regulation up to 0.92 in long-term regime, plays the same important role for Syrdarya.

Table 2

Water balance in section of Toktogul waterworks facility over 1995-2007, billion m^3

Year	Water volume in the reservoir by 01.10.	Inflow to reservoir			Releases from reservoir		
		year	growing season	non-growing season	year	growing season	non-growing season
1995	15.77	10.89	7.88	3.01	15	6.33	8.67
1996	15.19	13.7	10.94	2.76	14.53	6.16	8.37
1997	11.79	10.83	8.09	2.74	13.68	6.08	7.6
1998	15.07	14.49	11.5	2.99	11.16	3.68	7.48
1999	16.27	14.47	11.01	3.46	13.47	5.07	8.4
2000	13.7	12.6	9.19	3.41	15.2	6.48	8.72
2001	12.1	12.6	9.29	3.31	14.2	5.91	8.29
2002	17.4	16.7	13.51	3.19	11.4	3.65	7.75
2003	19.53	15.67	12	3.67	14.19	4.93	9.26
2004	19.19	14.46	10.84	3.62	14.94	6.23	8.71
2005	18.82	13.7	10.3	3.4	14.1	5.15	8.95
2006	17.15	12.6	9.5	3.1	14.3	5.29	9.01
2007	13.73	12	8.9	3.1	15	5.7	9.3
average	15.82	13.44	10.23	3.21	13.94	5.44	8.50

3. However, it should be kept in mind that construction of reservoirs does not mean that the long-term regulation regime is followed. A representative example is the actual operating regime of Toktogul waterworks in the last six years (Table 2). Though flow probability in the Naryn River was quite high, except for 2006…2007, Toktogul continuously released much more quantities of water than was planned and practically operated in such regime when inflow was released. In the last two years that were close to normal ones in terms of water availability 5 billion cubic meters of water were drawn down. In normal years, releases under long-term regulation regime should not be more than 12.2 km^3/year, including 6 km^3 in growing season and 6.2 km^3 in non-growing season during a low-water year. Actually, above those maximum allowable annual quantities Toktogul released 1.5-2 cubic meters more both in growing and non-growing seasons. As a result, in low-water period this caused potential draw down of Toktogul to dead-volume. Thus, it is necessary to set strict order and mechanism to ensure retention of long-term regulation facilities, obviously, by organizing joint management of cascade (as proposed by Kazakhstan) or establishing financial relations for accumulation and conservation of a portion of flow to the benefit of downstream countries (a kind of purchase of some reserve for its release in a low-water period).
4. Water use limits need to be revised in irrigation. Currently all the countries apply outdated, non-unified norms that are oriented to 20-30-year-old water-allowance zoning. Nowadays, water-allowance zones undergo great changes; however, mechanically, calculations of water needs are based on conditions that are far from reality. The command area of South-Fergana canal (Fergana part) can be used as an example to show changes in ratio between areas of different water-allowance zones. Due to the change in hydrogeological and soil conditions, the total area of water-allowance zones 1, 2 and 3 decreased by 33 thousand ha, the total area of zones 4, 5, and 6 increased by 13 thousand ha, and the total area of zones 7, 8, and 9 extended to 20 thousand ha (Table 3).

Table 3

Change in area of water-allowance zones, Fergana part of South-Fergana canal

Groundwater level, m	>3		2-3		1-2
Water-allowance zone		Water-allowance zone		Water-allowance zone	
1	-691.82	4	+2283.01	7	+2894.49
2	-18192.29	5	+8490.92	8	+14224.46
3	-14095.58	6	+2071.08	9	+3015.73
Total	-32979.69		+12845.01		+20134.68

5. Overestimated water supply norms create a large stage for water-management institutions to divert excessive water quantities into canals. This substantially reduces managerial efficiency coefficient of canals. Establishing order in water accounting and applying IWRM tools in two pilot canals - SFC in Uzbekistan and AAC in Kyrgyzstan - allowed the reduction of withdrawals and the improvement of managerial efficiency coefficient without considerable costs. (Figures 3a and 3b)

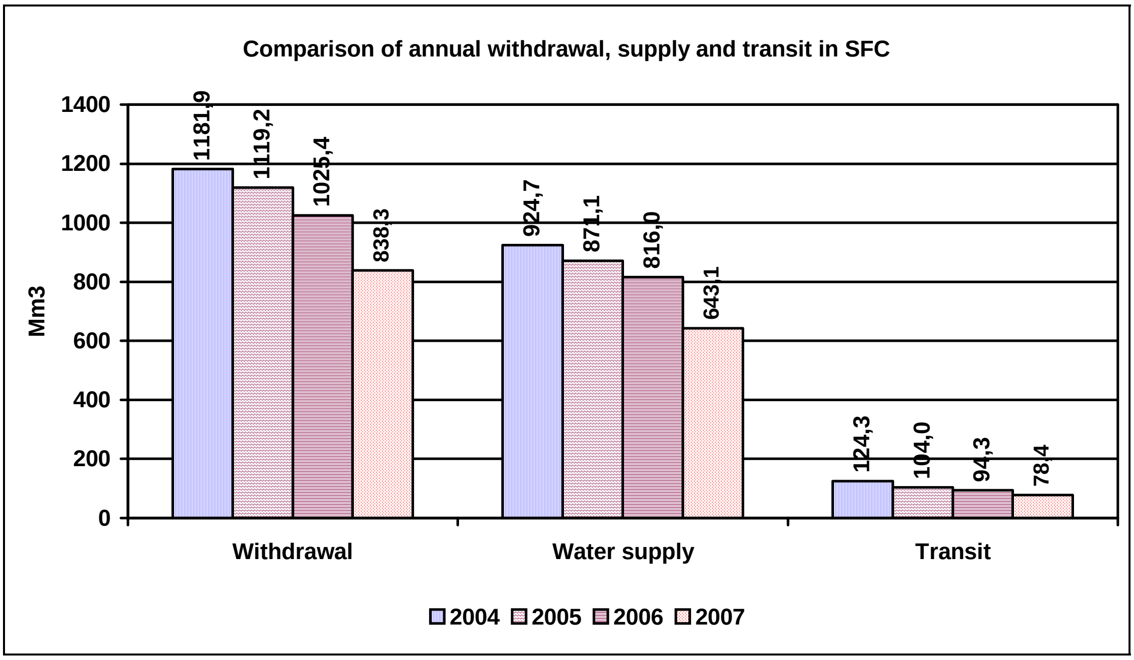

Figure 3a

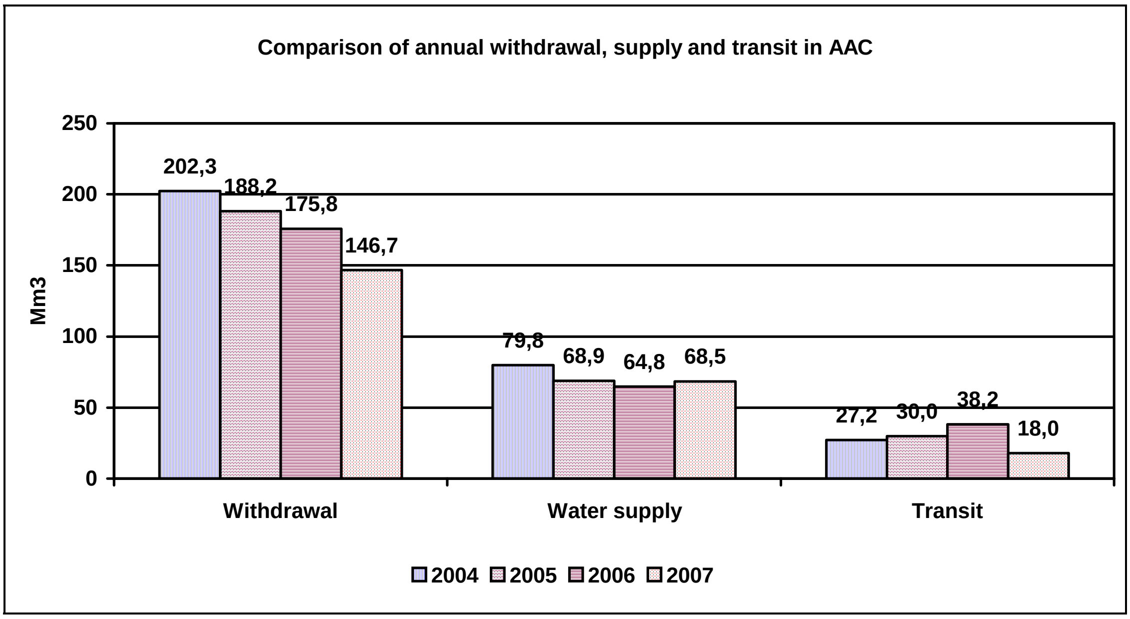

Figure 3b

Another direction to reduce surface water withdrawals is the use of surface water together with ground and return waters. This should be definitely included in water use plans.

6. The main way for survival under conditions of future *periodical* water shortage, let alone continuous one, should be a certain governance system providing for incentives for water conservation in farms, WUA, and field, first of all, by establishing strict water tariffs differentiated depending on degree of using the limit, as well as by introducing a system of encouragement for water saving.
7. It should be noted that the adaptation to climate change implies both adaptation to negative consequences and usage of occurring positive potentialities. The table below shows that there are a lot of such positive potentialities. Israeli practice shows an excellent example of the approach to water conservation promotion. Water cost in the water-supply system (Mekorot) is 0.4 $\$/m^3$. Municipalities and industry pay this price for water supplied. Municipality sells water using progressive tariff:
   a. initial 8 m^3 of water per month – 0.60 $\$/m^3$;
   b. further 7 m^3 of water per month – 0.88 $\$/m^3$;
   c. extra amounts – 1.2 $\$/m^3$;

   Industry pays 0.4 $\$/m^3$ for clean water;

   - 0.32 $\$/m^3$ for partially treated water;
   - no charge for usage of brackish water.

   Agriculture is subsidized. Initial 50% of the licensed limit of clean water is charged as 0.19 $\$/m^3$; further 50-80 % - 0.23 $\$/m^3$; and extra amount – 0.30 $\$/m^3$;

   As to partially treated water, agriculture pays 0.13 $\$/m^3$ for initial 50% of the limit and 0.10 $\$/m^3$ for further amount.

Table 4

Impact of climatic factors

Climatic parameters	Impacts	
Air temperature	The growing season extends	+
	Sowing dates - possibility for earlier sowing of double crops	+
	Conditions suitable for germination, phenological phases and growth	±
	Extremely high temperatures stop physiological processes in plants	-
Air humidity	Intensive evaporation	-
	Creates conditions for heat-and-moisture exchange essential for every specific crop	+
Precipitation	Soil moisture and humidity create natural moistening, conditions for growth and stability of sprouts	+
	Storm precipitation can impede germination and carrying out agricultural activities	-
Temperature, moisture and precipitation	Generally form plant evapotranspiration	+
	Change salinization processes	-
CO_2 concentration	Determine rate of photosynthesis, respiration	-
	Form biomass and productivity of crops	+

The Aral Sea basin being the northernmost zone for growing cotton, the major agricultural crop in the region, is not provided with sufficiently sustainable conditions for growing cotton and gaining guaranteed yields. However, rise in temperature implies that the northern territories take on the climatic properties of the southward territories, and the zone of possible cotton plantings would extend. Increase in the duration of potential growing season gives hope for possibility to gain yields twice a year. Accordingly, sowing dates would change, and it is already impossible to orientate to their average values. The rise in temperature and carbon dioxide concentration in the environment positively impacts upon growth and development of plants. Under climate change, potential yields of particular crops increase on condition that they are provided with primary production factors, nutrients, water, and protection. Climate change makes agricultural workers reconsider principles of management in crop growing. As under conditions of rise in temperature and moisture, change in river flow, all the process chain should undergo some changes. A special attention should be given to development of extension services for water use, which would serve and inform farmers of change in evapotranspiration and necessary correction in irrigation terms and amounts. These measures can reduce water withdrawals by 15-30% in average and high water years.

As a part of the "Adapt" Project together with the McGill University of Canada, we (G.V. Stulina) carried out experiments under working conditions on use of positive factors of climate change in irrigated agriculture. For that, imitation of new heat-insulating factors was carried out using film coating and furrow irrigation, which enabled us to improve water productivity (kg/m^3) up to 60% in growing cucurbits and vegetables. For adaptation measures, it is also very effective to change cropping pattern. As double crops following grain crops, we recommended growing legumes: Russian bean, soybean and green gram. In addition to being vegetable protein source, these crops improve land productivity, producing organic nitrogen and consuming only 1,500-2,000 m^3/ha per season. The climate aridization evident through the occurrence of stressed dry years forces to solve the food security problem by replacing industrial crops with food crops: vegetables, cucurbits.