CLIMATIC CHARACTERISTIC OF SYRDARYA RIVER BASIN

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Introduction

Territory of Syrdarya River basin has complex geographical structure. Northern part for the middle and lower flow of Syrdarya River is submitted by extensive flat spaces with monotonous deserted and semidesert landscapes. For headwaters of Syrdarya River high altitude ridges and intramountain depressions of mountain systems with quickly varying numerous landscapes dominate (Figure 1). Territorial contrast and variety of landscapes reflects complexity of spatial distribution of climatic parameters and determines necessity of the detailed analysis with using of cartographical results of landscape-climatic modelling.

The analysis of existential distribution is executed for the following climatic characteristics:

1. Air temperature and its change depending on types of an underlying terrain;
2. The sums of a water layer and volumes for precipitations per elementary platform;
3. Evaporation in a water layer and volumes per elementary platform;
4. Water balance as a difference between precipitations and evaporation per elementary platform.

Besides for evaluating of a role of time transformation of a regional climate in time of intensive developing of Aralsky crisis for second part of twentieth century the analysis of interdecade changes for these climatic parameters is executed.

Evaluation of existential changes of climatic and water regime of Syrdarya River basin is executed on a basis of the measured climatic data, landscape and soil mapping, which a basis of landscape-climatic modelling were. Results of modelling are presented in the form of the tabulated data, charts and the thematic maps, which describing average conditions of the basic climatic indexes and a river flow.

Modelling is executed at observance of the following conditions:

- as a normal climatic status the period 1960-1969 is accepted;
- change of climatic parameters and river flow was estimated in relation to the normative period and among themselves on decades 1970-1979 and 1980-1989;
- for estimating of the average climatic status of each next decade as conditional date the middle of the period is accepted: 1965, 1975 and 1985;
- for each period parameters of winter, spring, summer and autumn seasons, and also the annual status were estimated.

As a result of modelling 224 maps of seasonal and annual temperatures, precipitations, evaporation and water balance and a map of change of their changes on decades have been received.

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General dynamic of water resources

According to the settled notion about Aralsk region in the season up to the middle of the sixtieth years economic activities are characterized by moderation and stability in use of water resources. The intensive attrition of water resources contacts breaking-in period of the new agricultural areas which most active phase falls at the seventh - eighth decades of XX century. In comparison by the sixtieth years in 1970-1989 years changes of a river flow of Syrdarya in the lower flow was characterized by resistant decreasing of volume of inflow in 1.2 ÷ 1.8 times. So, at a hydropost Kazalinsk in the sixtieth years the average river inflow on decades has made - 10.572 km^3, the seventieth years - 4.121 km^3, and the eightieth years - 2.256 km^3 (Figure 2).

Appreciable decreasing of inflow shows, beginning from a hydropost Uchkurgan where a difference between the sixtieth and seventieth years has made 22.8 %. Last significant relative decreasing of volumes of a river flow between the given seasons is marked in area of hydroposts Chinaz - Chardara where it values attains to 42.65 % for the seventh decade and 49.82 % for the eighth decade. These ratios are preserved down to a mouth of Syrdarya River.

Comparison of the modelled parameters of a water balance with the measured values of river inflow on closing hydroposts of the local basins composing whole Syrdarya River basin has revealed series of regularity**.**

The calculating water balance for local river inflows everywhere is higher than analogous parameters on a river flow. It speaks that on hydroposts the surface runoff while entries of a water balance give a total quantitative assessment surface and underground influx.

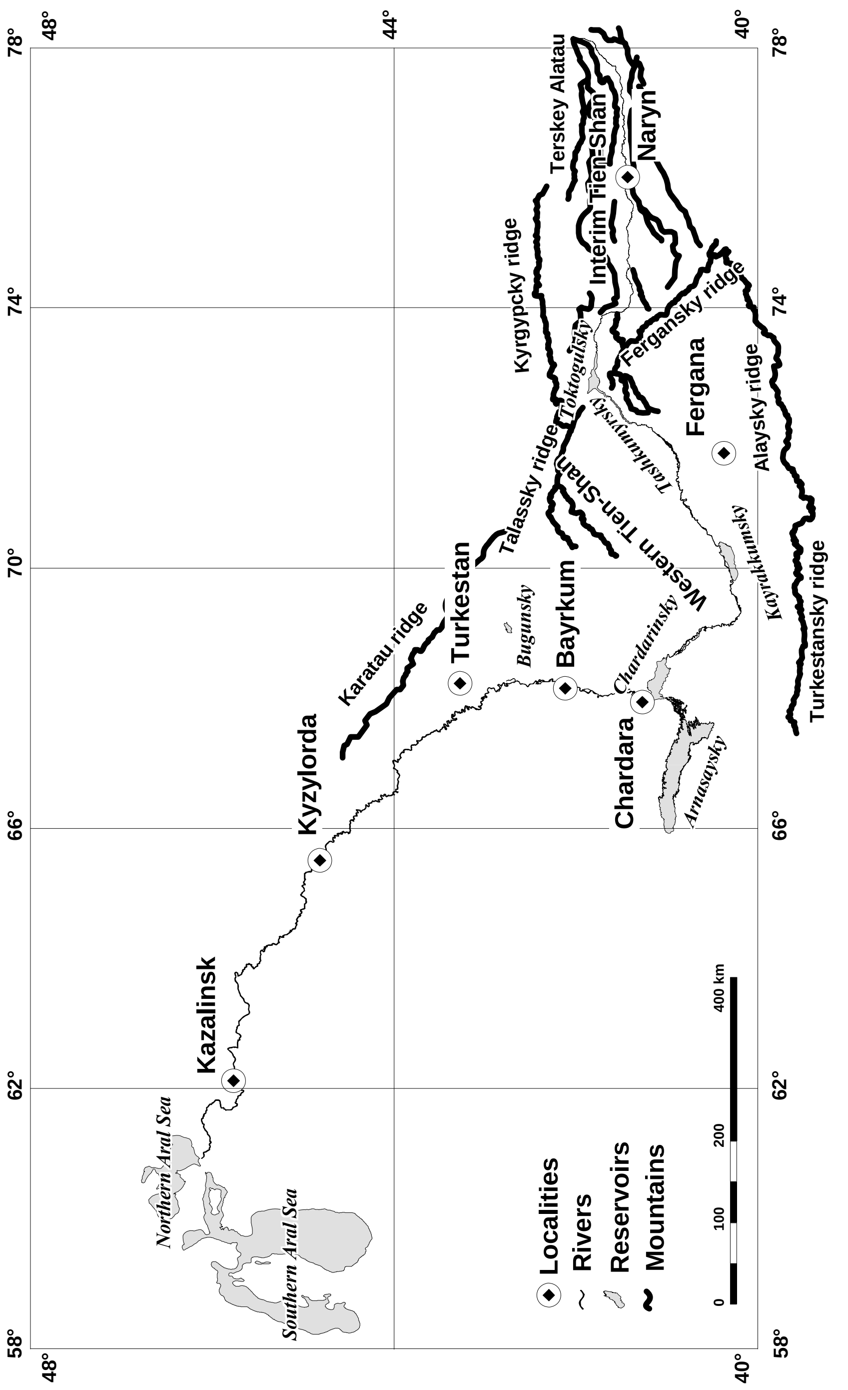

Figure 1. General map of Syrdarya River basin on 2003 year .

Insufficient using of a water potential of Syrdarya River basin it is possible to express through function of deficiency of real water storage by formula:

$$\Delta Vol\ (\%) = 100 * (Vol_{wb} - Vol_{in})/Vol_{wb},$$

where

Vol_{wb} – volume of a potential water balance;

Vol_{in} – volume of a river flow.

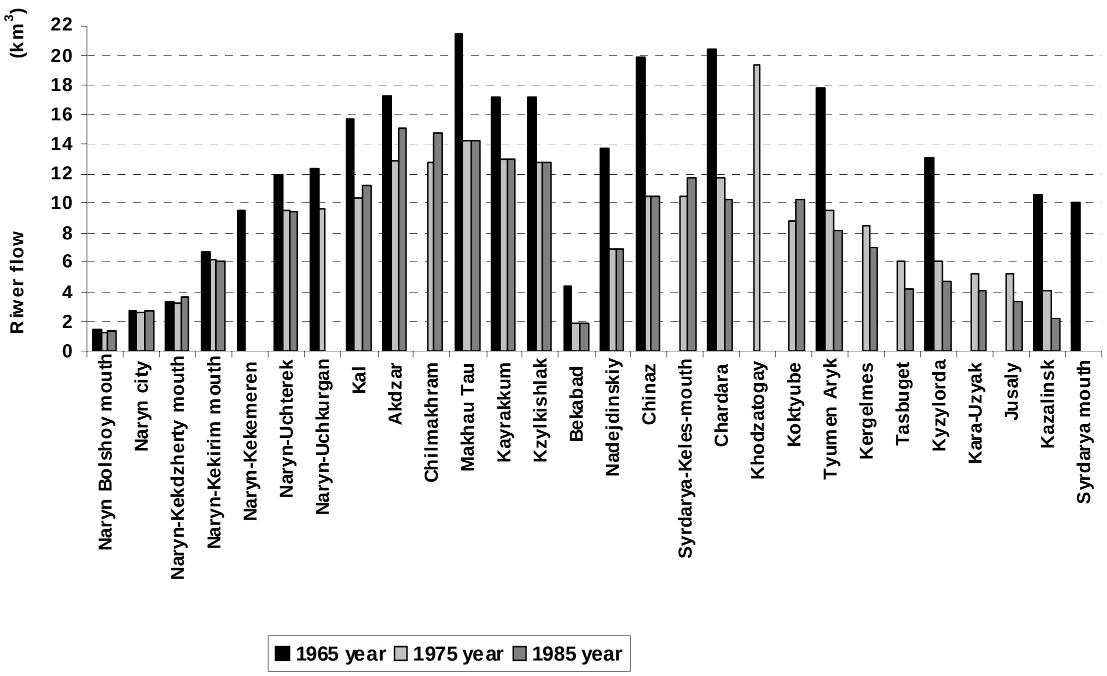

Figure 2. Change of Syrdarya River flow for 30 years.

Based on calculation of deficiency of water resources it is possible to estimate over-all profitableness of their use of resources by formula

$$Profitability=1/\Delta Vol.$$

The analysis of existential distribution of water deficiency has revealed specific regularity for use of water resources of Syrdarya River basin, which do not variate from decade by decade (Figure 3).

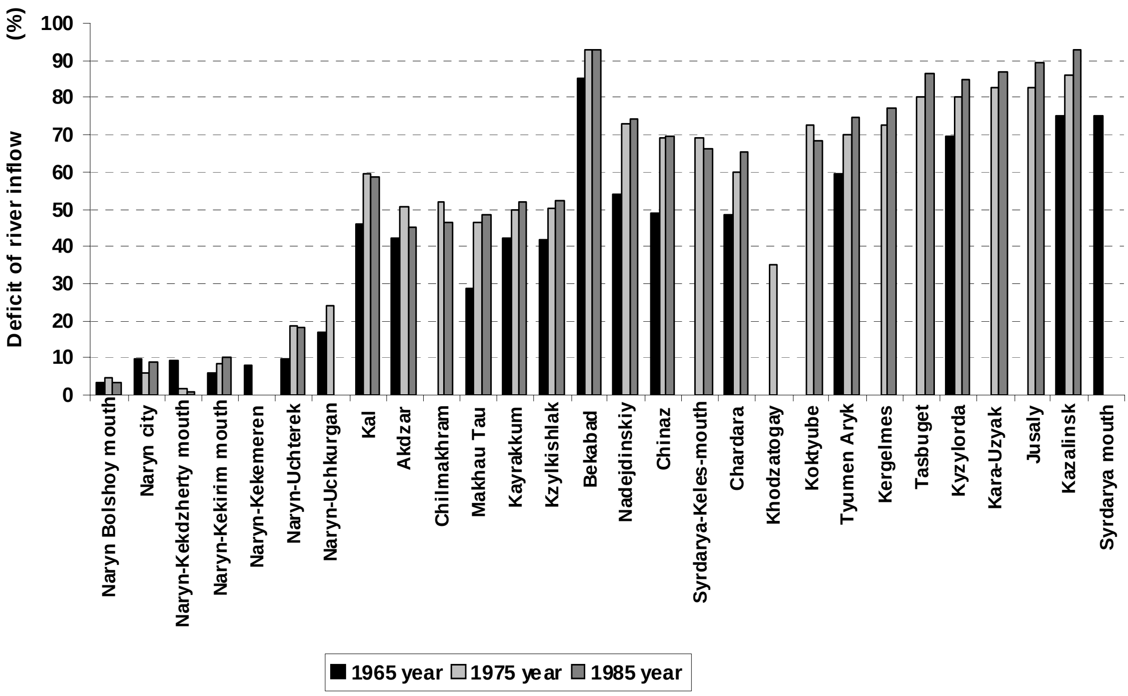

Figure 3. Deficiency of river inflow concerning of cumulative water balance (%).

Three are secreted confidently discernible zones of water management. The zone of headwaters of the basic inflows - the rivers Naryn and Karadarya from headstreams up to a hydropost Uchkurgan is characterized by a low level of retirement of water from the main race course, no more than 4÷22 %. In Fergansky valley from a hydropost Kal up to hydropost Kzylkishlak from the basic race course Syrdarya River it is withdrawn 30 ÷ 60 % of water stores. Thus magnitude of withdrawn volumes of water does not variate almost on all extent of Fergansky valley. Only in area of hydropost Bekabad the ratio of inflow to a potential water balance sharply contrasts with parameters typical for the given zone. For the lower flow Syrdarya River characteristic magnitudes of requisitioning are 65 ÷ 85 % from a total storage at steadily increasing deficiency of water resources on a direction to Syrdarya River mouth.

For the next decades the trends given considerably have amplified. Deficiency of water resources has increased up to 86.26 %. In area of hydropost Kazalinsk for seventieth years and for eightieth years deficiency of water resources has achieved 92.34 %. This was promoted by series of the causes, generalized, which analysis realized on summaries of landscape-climatic modelling.

At comparison of magnitudes of a potential water balance and a river influx it is possible to draw a resume that already to the sixtieth years all preconditions for fall of a level of Aral Sea have ripened. Losses about 75 % of annual water supply for Syrdarya River basin characterize a situation in region as intense and extremely non-resistant. At such regime of water using any intensification of economic activities unavoidably started the mechanism for the Aral catastrophe.

In the seventieth years group of large water reservoirs on the Naryn, Syrdarya rivers and their inflows are injected into exploitation. Besides as result of flood activity 1973 years on the Syrdarya River were created Arnasaysky reservoir, which functions and now.

The analysis of influence of the largest reservoirs on redistribution of water resources of Syrdarya River basin shows, that the biggest withdrawals of water account for three water reservoirs - Kayrakkumsky, Arnasaysky and Chardarinsky, which the territories located in southern hottest flat area (Figure 4).

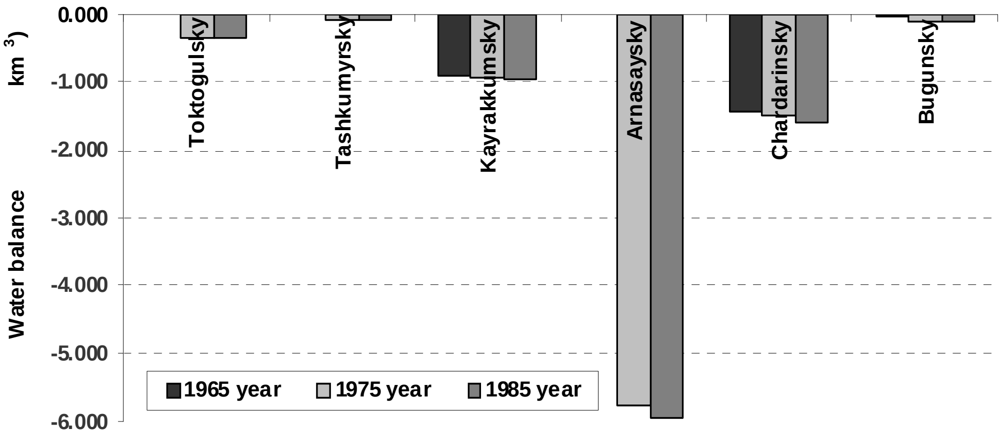

Figure 4. Water balance of more large reservoirs of Syrdarya River basin for 30 years.

For seventieth years common losses of water store conditioned of evaporation for all large reservoirs were equal -8.70 km^3/year and water losses from Kayrakkumsky, Arnasaysky and Chardarinsky reservoirs was equal -8.17 km^3/year or 94.97 % from total value. For eightieth years common water losses of same reservoirs were equal -8.97 km^3/year, water losses from Kayrakkumsky, Arnasaysky and Chardarinsky reservoirs were equal - 8.46 km^3/year or 94.28 % from total value. Losses of water resources from only one Arnasaysky reservoir have made accordingly:

- for the seventieth years --5.76 km^3/year or 66.20 % from total amount;
- for the eightieth years --5.94 km^3/year or 66.29 % from total amount.

On the seventieth years it was necessary peak of construction and modernization of net cannels in zones for irrigation farming. All this has resulted in essential redistribution of water stores inside basin in such manner that the significant part of water remained in numerous water reservoirs and collector discharge water and not attaining to Aral Sea.

The given deduction proves to be true at comparison of regimes of water using and character economic activity of the seventieth and eightieth years (Figure 3). The basic difference of the season of 1980-89 from the last decade was that on change to a scale hydrotechnical construction there has come an intensification of exploitation of irrigated agricultural terrains in the lower flow of Syrdarya River due to expansion of the areas under water consumption crops of rice and cotton. As shows the relative analysis, expansion of the areas under water consumption crops in the eightieth years has resulted increasing of deficiency of a river inflow at 5 % from a level of 1970-79 years.

Detailed differentiation of the causes of decreasing of water resources of Syrdarya River basin and the evaluation of their contribution realized with use of cartographical results of modelling of climatic characteristics.

From all collections of the modelling cartographical data for an evaluation of climatic changes in Syrdarya River basin the most representative results picked. The analysis realized under the over-all circuit scheme:

1. The description of the status of climatic annual value of a parameter for the base season (it is conditional 1965 year);
2. The description of the annual status of value of a climatic index for the seventieth years (it is conditional 1975 year) and the eightieth years (is conditional 1985 year);
3. The detailed description of changes of the status of value of an annual climatic index on seasons and between the period of the sixtieth, seventieth and eightieth years.

For thirty years from 1960 until 1990 changes of a river drain of the basic bed of Syrdarya in area of hydropost Kazalinsk was characterized by steady decreasing in 2 ÷ 2.2 times for a decade. Decreasing of a drain Syrdarya River an absolute values looks even more impressing:

1965 year — 10.572 km^3,

1975 year — 4.121 km^3,

1985 year — 2.256 km^3.

The estimation of distinctions of values of water balance from a decade by a decade shows essential influence of changes of a climatic situation on fluctuations of a water mode Syrdarya River (Table 1). Last three columns of the table characterize changes of water balance between decades. They show on series of local basins of Tien-Shan decreasing of water balance in a zone of feed in the seventieth and eightieth years up to 38 % from a condition of the middle of the sixtieth years.

The detailed analysis of the reasons of degradation of water resources of Syrdarya River basin and the estimation of their contribution is executed using of cartographical results of modelling for climatic characteristics.

Results of modelling are submitted in the form of the tabulated data and thematic maps describing the annual status of the basic climatic parameters for the following periods:

For temperature-humidifying norms conditional date – 1965 is accepted:

For an estimation of the average climatic status of each next decade as conditional date the middle of decade is accepted;

For climatic differences between norms and average conditions on decades and between decades the conditional dates designated by last in two figures of norm or the next decade are accepted.

Comparison of the sums of annual water balance on local river basins, forming the whole Syrdarya basin, with the measured values of a river drain on closing hydroposts to local basins as of 1965 has revealed a range of regularities (Table 1).

The designed water balance for all decades everywhere appeared above the data on a river drain. It speaks that the calculated values of water balance comprise also an underground component of a drain while on hydroposts the superficial drain is registered only.

In the sixtieth years in local river basins, where economic activities were insignificant or was absent, excess of water balance over a river drain were in a range 1 ÷ 10 %. On the average and the bottom current Syrdarya River, essential divergences between forecasting and the measured data were observed within the limits of 11÷ 75 %. Check of a hydrological mode on independent sources [1] has shown that in local pools with the big deficiency of a river drain the ramified networks of irrigational channels are located. Therefore, the part of water proceeds on channels by a closing hydropost and is lost for it irrevocably.

For the given treatment the term - "irrevocable" is understood not only as the full loss of the water, which have come as a result of economic activities but also as the withdrawn water resources of local pool, it is in part or completely returned for its borders.

As example of last variant of interpretation of the term - "irrevocable" the situation developed in Karakoin River basin. Here the difference between the designed water balance and river drain made -24.41 %. At the same time, in area of hydropost Dzangistal, which is located below a confluence of inflow Karakoin to Atbashi River, the difference between the calculated value of water balance and the measured drain makes about 5 %. For direct value of this term irrevocable losses of water are observed in the bottom current Syrdarya River, starting from a place of junction Naryn and Karadarya Rivers up to a mouth Syrdarya River. Deficiency of water resources increasing to Aral Sea on the basic channel of the river in area of Kazalinsk achieved by 1965 of value -74.89 % from potential water balance.

Table 1. Comparison of calculated water balance and measured river inflow of Syrdarya River

Name of river basin (hydroposts)	Water balance 1965 (km^3)	River inflow 1965 (km^3)	Difference balance & inflow 1965 (%)	Water balance 1975 (km^3)	River inflow 1975 (km^3)	Difference balance & inflow 1975 (%)	Water balance 1985 (km^3)	River inflow 1965 (km^3)	Difference balance & inflow 1985 (%)	Delta water balance 75-65 (km^3)	Delta water balance 85-65 (km^3)	Delta water balance 85-75 (km^3)
1	2	3	4	5	6	7	8	9	10	11	12	13
Aral Sea	***-51.256***			***-56.715***			***-55.849***			***-5.459***	***-4.593***	***0.866***
Total Syrdarya basing, including:	***39.878***	***10.004***	***74.914***	***25.645***			***26.074***			***-13.885***	***-13.803***	***0.297***
Naryn Bolshoy mouth	1.579	1.524	3.466	1.328	1.268	4.495	1.469	1.419	3.402	-0.251	-0.110	0.142
Naryn Maly mouth	1.433	1.365	4.771	1.259	1.210	3.904	1.315	1.277	2.826	-0.174	-0.119	0.055
Naryn city	3.117	2.819	9.552	2.774	2.605	6.103	3.102	2.826	8.890	-0.343	-0.015	0.328
Onarcha - Onarcha	0.327	0.319	2.529	0.332	0.319	3.924	0.266	0.259	2.817	0.004	-0.061	-0.066
Dzhergetal - Dzhergetal	0.032	0.030	5.999	0.027	0.026	3.637	0.042	0.040	3.507	-0.005	0.010	0.014
Kekdzherty - Aktala	0.170	0.168	1.454	0.112	0.106	5.420	0.185	0.176	4.737	-0.058	0.014	0.072
Naryn - Kekdzherty mouth	3.672	3.326	9.431	3.302	3.254	1.451	3.707	3.679	0.776	-0.370	0.035	0.406
Atbashi - Ichke-Kamandy mouth	0.602	0.586	2.609	0.553	0.522	5.669	0.536	0.504	5.899	-0.049	-0.067	-0.017
Karakoin - Karakoin	0.055	0.044	20.663	0.049			0.046			-0.006	-0.009	-0.003
Atbashi - Dzangistal	1.094	1.045	4.533	1.017			0.919			-0.077	-0.175	-0.098
Alabuga - Koshtobe	0.860	0.829	3.590	0.958	0.920	3.986	1.137	1.104	2.882	0.098	0.276	0.178
Kekirim - Kara-Tabylga	0.698	0.666	4.602	0.648	0.604	6.709	0.587	0.574	2.229	-0.050	-0.110	-0.060
Naryn - Kekirim mouth	7.058	6.648	5.819	6.793	6.230	8.289	6.785	6.092	10.211	-0.265	-0.273	-0.008
Karakol mouth	0.739	0.707	4.404	0.612	0.585	4.354	0.848	0.819	3.453	-0.127	0.109	0.236
Kekemeren - Karakol	1.258	1.232	2.102	1.169	1.162	0.586	1.265	1.221	3.470	-0.089	0.007	0.096
Orto-Kugandy	0.121	0.116	4.473	0.100			0.129			-0.021	0.007	0.029
Dzhumgol - Chaek	0.365	0.339	7.143	0.263	0.248	5.560	0.274	0.252	8.056	-0.102	-0.091	0.012
Kekemeren - Dzhumgol	2.094	2.092	0.102	2.467	2.416	2.034	2.026			0.372	-0.068	-0.440
Kekemeren - Dzhumgol mouth	2.489	2.482	0.274	2.663	2.323	12.773	2.460	2.417	1.727	0.175	-0.029	-0.203
Naryn - Kekemeren	10.433	9.594	8.043	10.223			9.780			-0.209	-0.653	-0.443
Torkent - Torkent	0.397	0.373	5.954	0.362	0.349	3.638	0.283	0.271	4.194	-0.035	-0.114	-0.080
Chichkan - Bala-Chichkan	0.631	0.598	5.218	0.466	0.449	3.546	0.514	0.488	5.157	-0.165	-0.116	0.049
Uzunakhmat - Ustasay mouth	0.983	0.927	5.718	0.801	0.763	4.800	0.954	0.911	4.600	-0.182	-0.029	0.153
Naryn - Uchterek	13.219	11.912	9.887	11.703	9.548	18.409	11.509	9.461	17.795	-1.517	-1.710	-0.193
Aflatun - Aflatun	0.357	0.345	3.358	0.336	0.326	3.080	0.391	0.366	6.493	-0.021	0.035	0.055
Karasu right mouth	1.381	1.317	4.652	1.142	1.106	3.159	1.550			-0.239	0.169	0.408
Naryn - Uchkurgan	14.894	12.382	16.867	12.741	9.686	23.973	13.008			-2.153	-1.886	0.267

Continuation of Table 1

1	2	3	4	5	6	7	8	9	10	11	12	13
Tar - Cholma	1.477	1.414	4.261	1.622	1.597	1.525	1.890	1.782	5.714	0.145	0.413	0.269
Karakuldzha - Aktash	0.709	0.674	4.914	0.741	0.728	1.715	0.838	0.785	6.392	0.032	0.130	0.097
Kulduk - Sarybulak	0.080	0.075	5.268	0.074	0.073	1.062	0.110	0.106	3.825	-0.006	0.030	0.036
Yassy - Salamalik	0.736	0.698	5.069	0.681	0.645	5.360	0.696	0.664	4.649	-0.055	-0.039	0.015
Donguztau - Donguztau	0.094	0.088	7.260	0.083	0.078	6.235	0.090	0.088	1.663	-0.012	-0.005	0.007
Zerger - Tassay	0.091	0.091	0.529	0.091	0.088	3.171	0.104	0.102	2.055	0.000	0.012	0.012
Yassy - Uzgen	1.187	1.057	10.924	1.097			1.170			-0.090	-0.017	0.073
Changet - Changet	0.074	0.070	5.425	0.066	0.064	2.659	0.075	0.071	5.641	-0.008	0.002	0.010
Kugart - Mikhaylovka	0.614	0.574	6.516	0.567	0.548	3.383	0.618	0.603	2.380	-0.047	0.004	0.051
Tentyaksay - Charvak	0.971	0.916	5.654	0.757	0.713	5.817	1.013	0.978	3.445	-0.214	0.042	0.256
Shaydansay - Shaydan	0.055	0.052	4.210	0.056	0.054	2.671	0.068	0.067	1.870	0.001	0.013	0.012
Maylisu - Kayragach mouth	0.295	0.276	6.362	0.310	0.294	5.181	0.306	0.297	2.957	0.015	0.010	-0.005
Kurshab - Gulcha	0.563	0.542	3.745	0.475	0.472	0.649	0.654	0.625	4.428	-0.089	0.090	0.179
Kurshab - Kochkor-Ata	0.835	0.779	6.643	0.709			0.931			-0.126	0.096	0.222
Akbura - Mynteke mouth	0.122	0.121	0.977	0.121			0.139			-0.001	0.017	0.018
Akbura - Papan	0.635	0.607	4.440	0.635	0.587	7.521	0.694	0.635	8.426	0.000	0.059	0.059
Akbura - Tuleken	0.688	0.668	2.926	0.677	0.588	13.121	0.742	0.714	3.805	-0.012	0.054	0.065
Karakol - Koschan	0.057	0.055	3.190	0.055	0.052	4.986	0.067	0.064	4.918	-0.002	0.011	0.012
Kirgizata - Kirgizata	0.138	0.131	5.029	0.140	0.133	4.770	0.148	0.142	4.253	0.002	0.011	0.009
Shankol - Shankol	0.031	0.029	4.740	0.031			0.031			0.000	0.000	0.000
Aravansay - Yanginaukat	0.206	0.196	5.205	0.205	0.194	5.298	0.207	0.194	6.179	-0.001	0.001	0.002
Aravansay - Karakol mouth	0.433	0.327	24.399	0.428	0.212	50.359	0.451	0.211	53.157	-0.005	0.019	0.024
Abshirsay - Uchterek	0.053	0.053	0.353	0.046	0.044	3.571	0.055	0.053	2.393	-0.007	0.002	0.009
Isfayramsay - Lyangar	0.293	0.277	5.217	0.247			0.270			-0.046	-0.023	0.023
Isfayramsay - Uchkorgon	0.787	0.705	10.484	0.650	0.613	5.633	0.766	0.672	12.284	-0.137	-0.022	0.116
Koksu mouth - Kurbankul	0.079	0.075	4.633	0.071			0.086			-0.008	0.008	0.016
Sakhimardan -Lyangar	0.349	0.311	10.903	0.333			0.371			-0.008	0.022	0.038
Sokh - Sarykanda	1.374	1.304	5.057	1.373	1.312	4.417	1.450			-0.016	0.076	0.077
Isfara - Tashkurgan	0.488	0.476	2.483	0.485	0.452	6.887	0.456	0.435	4.651	-0.003	-0.032	-0.029
Isfara - Isfara	0.589	0.451	23.400	0.564			0.525			-0.025	-0.064	-0.040
Khodzhabakirgan - Andarkhan	0.347	0.332	4.181	0.324	0.294	9.194	0.293	0.277	5.379	-0.023	-0.053	-0.031
Aksu-Dazgon	0.123	0.122	1.158	0.117	0.113	3.620	0.121	0.114	6.063	-0.006	-0.002	0.004
Padshaata - Tostu mouth	0.207	0.198	4.630	0.165	0.157	4.677	0.162	0.155	4.218	-0.042	-0.045	-0.003
Alabuka - Alabuka	0.084	0.080	4.990	0.068			0.079			-0.016	-0.005	0.011
Uryukty mouth	0.016	0.015	3.684	0.012			0.012			-0.003	-0.003	0.000
Kassansay - Uryukty mouth	0.311	0.282	4.475	0.270			0.286			-0.040	-0.025	0.016
Kassansay - Baymak	0.449	0.341	24.151	0.383			0.409			-0.067	-0.040	0.026

Continuation of Table 1

1	2	3	4	5	6	7	8	9	10	11	12	13
Sumsar - Sumsarsay	0.033	0.032	2.879	0.027			0.025			-0.005	-0.007	-0.002
Syrdarya - Kal	29.079	15.733	45.897	25.752	10.386	59.669	27.054	11.238	58.461	-3.327	-2.025	1.302
Gavasay - Ters mouth	0.164	0.157	4.324	0.143			0.138			-0.020	-0.026	-0.005
Gavasay - Gava	0.253	0.190	24.764	0.220	0.164	25.476	0.212	0.132	37.723	-0.033	-0.041	-0.003
Chadak - Dzulaysay mouth	0.125	0.120	4.676	0.110			27.332			-0.016	-0.023	-0.008
Syrdarya - Akdzar	29.768	17.290	41.917	26.196	12.929	50.643	27.442	15.058	44.908	-3.573	-2.436	1.136
Syrdarya - Chilmakhram	29.991			26.357	12.707	51.789	27.452	14.743	46.276	-3.634	-2.549	1.085
Syrdarya - Makhau Tau	30.035	21.399	28.754	26.383	14.161	46.323	26.767	14.161	48.413	-3.653	-2.583	1.069
Syrdarya - Kayrakkum	29.489	17.143	41.866	25.740	12.950	49.690	26.800	12.950	51.620	-3.749	-2.722	1.027
Syrdarya - Kzylkishlak	29.555	17.218	41.742	25.786	12.805	50.341	26.832	12.805	52.221	-3.770	-2.755	1.014
Syrdarya - Bekabad	29.644	4.392	85.185	25.842	1.969	92.382	26.838	1.969	92.663	-3.802	-2.812	0.990
Syrdarya - Nadejdinsky	29.862	13.782	53.848	25.898	6.945	73.185	26.838	6.945	74.124	-3.964	-3.024	0.940
Akhangaran - Yakaarcha	0.472	0.448	4.997	0.478			0.470			0.006	-0.002	-0.008
Akhangaran - Turk	0.893	0.833	6.668	0.926			0.789			0.033	-0.104	-0.136
Akhangaran - Soldatskoe	0.843	0.738	12.381	0.857			0.712			0.014	-0.131	-0.145
Ters mouth	0.300	0.284	5.219	0.284	0.268	5.729	0.277			-0.016	-0.023	-0.007
Chatkal - Ters mouth	2.238	2.136	4.588	2.163	2.089	3.405	2.061	1.965	4.635	-0.076	-0.177	-0.102
Chatkal - Nayza mouth	2.775	2.657	4.240	2.634			2.535			-0.141	-0.240	-0.099
Koksu - Burchmulla	0.382	0.366	4.181	0.371			0.353			-0.011	-0.029	-0.019
Oygaing mouth - Karangitugayskaya	0.907	0.868	4.284	0.893			0.937			-0.014	0.030	0.044
Maidantal mouth - Karangitugayskaya	0.495	0.470	4.945	0.483			0.526			-0.012	0.031	0.043
Pskem mouth - Charvakskaya	2.737	2.553	6.710	2.654			2.706			-0.083	-0.031	0.052
Ugam - Khodzikent	0.695	0.660	5.065	0.653			0.638			-0.042	-0.057	-0.016
Chirchik - Khodzikent	7.017	6.954	0.901	6.707			6.591			-0.311	-0.426	-0.116
Chirchik - Gazalkent	7.211	7.132	1.095	6.896			6.757			-0.315	-0.454	-0.139
Chircik mouth	8.026	3.093	61.469	7.668			7.439			-0.358	-0.588	-0.230
Syrdarya - Chinaz	38.573	19.834	48.581	34.228	10.509	69.298	34.772	10.509	69.778	-4.345	-0.623	0.544
Syrdarya – Keles mouth	38.665			34.292	10.479	69.443	34.837	11.740	66.301	-4.373	-0.495	0.545
Keles - Stepnoe	0.227	0.164	27.574	0.372			0.478			0.145	0.251	0.106
Keles mouth	0.260	0.208	20.194	0.405	0.342	15.675	0.610	0.445	27.015	0.145	0.350	0.205
Syrdarya - Chardara	39.670	20.449	48.451	29.148	11.728	59.764	29.333	10.261	65.019	-10.521	-10.337	0.184
Syrdarya - Khodzatogay	40.465			29.596	19.282	34.850	29.846				-10.618	0.066
Sayram - Blinkovo	0.248	0.237	4.355	0.247			0.236			-0.001	-0.012	-0.011
Boldybrek - Sakharovka	0.099	0.095	3.972	0.098			0.106			-0.001	0.007	0.008
Aksu - Podgornoe	0.360	0.301	16.344	0.365			0.379			0.005	0.019	0.006
Dzebaglysu - Novo-Nikolaevka	0.078	0.074	4.164	0.083			0.085			0.005	0.007	0.002

Continuation of Table 1

1	2	3	4	5	6	7	8	9	10	11	12	13
Arys - Dzusansay	1.232	0.959	22.152	1.208			1.195			-0.024	-0.037	-0.017
Badam - Pervomayskoe	0.043	0.040	6.895	0.040			0.036			-0.003	-0.007	-0.004
Borolday - Karla Marksa	0.363	0.341	5.985	0.336			0.342			-0.026	-0.021	0.005
Balabugun - Kitaevka	0.042	0.039	7.367	0.037			0.038			-0.005	-0.004	0.001
Almaly - Orlovka	0.019	0.017	7.906	0.017			0.017			-0.002	-0.001	0.000
Kattabugun - Leontievka	0.109	0.098	10.372	0.099			0.100			-0.010	-0.008	0.001
Bugun - Red Bridge	0.434	0.138	68.188	0.378			0.390			-0.055	-0.043	0.009
Arys - Arys	2.927	1.019	65.181	2.636	0.646	75.494	2.593	0.454	82.494	-0.291	-0.334	-0.043
Arys - Shaulder	2.976	0.720	75.826	2.665			2.623			-0.311	-0.354	0.001
Shayan - Akbet	0.099	0.080	19.716	0.086			0.105			-0.013	0.006	0.019
Arystandy - Algabas	0.056	0.036	35.217	0.049			0.074			-0.007	0.018	0.025
Syrdarya - Koktyube	44.107			32.233	8.788	72.736	32.365	10.333	68.073	-11.045	-11.742	-0.120
Syrdarya - Tyumen Aryk	44.026	17.767	59.644	31.959	9.599	69.965	31.976	8.185	74.404	-11.719	-12.050	-0.116
Kergelmes	43.446			30.989	8.451	72.729	30.988	7.062	77.210	-12.110	-12.458	-0.017
Syrdarya - Tasbuget	43.350			30.876	6.165	80.034	30.893	4.202	86.398	-12.127	-12.457	0.018
Syrdarya - Kyzylorda	43.303	13.121	69.698	30.819	6.134	80.096	30.850	4.739	84.639	-12.137	-12.452	0.015
Syrdarya - Kara-Uzyak	43.226			30.721	5.312	82.710	30.784	4.061	86.808	-12.158	-12.442	0.031
Syrdarya - Jusaly	42.535			29.825	5.209	82.533	30.017	3.305	88.991	-12.363	-12.518	0.129
Syrdarya-Kazalinsk	42.157	10.572	74.923	29.313	4.121	85.941	29.445	2.256	92.338	-12.498	-12.712	-0.060

** Source of data for Syrdarya River floe are Kazakhstan Hydrometeo Service and Kyrgyzstan Hydrometeo Service*

The next decades the tendencies given considerably have amplified. For hydropost Kazalinsk for the seventieth years deficiency of water resources has increased up to 86.26 %, and for the eightieth years it has achieved 92.34 %. This was promoted by a number of the reasons, generalized, which analysis is executed on results of landscape-climatic modelling.

Air temperature

Average of air temperature on decades

Average annual temperature regime of Syrdarya River basin as of 1965 year it is characterized by distribution of air temperatures as typical for arid climatic zones of moderate latitudes of the Central Asia (Figure 5). In a zone of arid plains of Syrdarya River basin character of temperature field in basic submits to regularity latitude distributions of temperatures with the small heterogeneities caused by effect humidified intrazonal and anthropogenic of changed landscapes. In mountain terrains it is determined by regularity of normal high-altitude distribution. Cooling effect of Aral Sea shows in extensive lowering average annual air temperatures above its aquatory on magnitude no more than 5 °C.

In more details the thermal regime of the Aral region for period up to the end of the sixtieth years circumscribed in publications [1, 2, 3, 4, 5].

At over-all similarity of a thermal regime of the seventieth and sixtieth decades the fields of average annual air temperatures of 1970 – 1979 years has some differences from the previous season (Figure 6). The space distribution of temperatures has got more mosaic character because of intensifying contrast of local heterogeneities of underlying terrain on the middle flow Syrdarya River.

The temperature regime of mountain areas of Internal Tien-Shan has the increased level on 0.5 ÷ 1 °C. Small increase of temperature on 0.8 ÷ 1.5 °C is registered for aquatory of Aral Sea and lower flow Syrdarya River.

In the eightieth years the field of average annual air temperatures differs from temperature field of antecedent decade a little, but has quieter character (Figure 7). Because of decreasing of aquatory of Aral Sea the regime of effect of underlying terrain in zone of a drained bottom has changed.

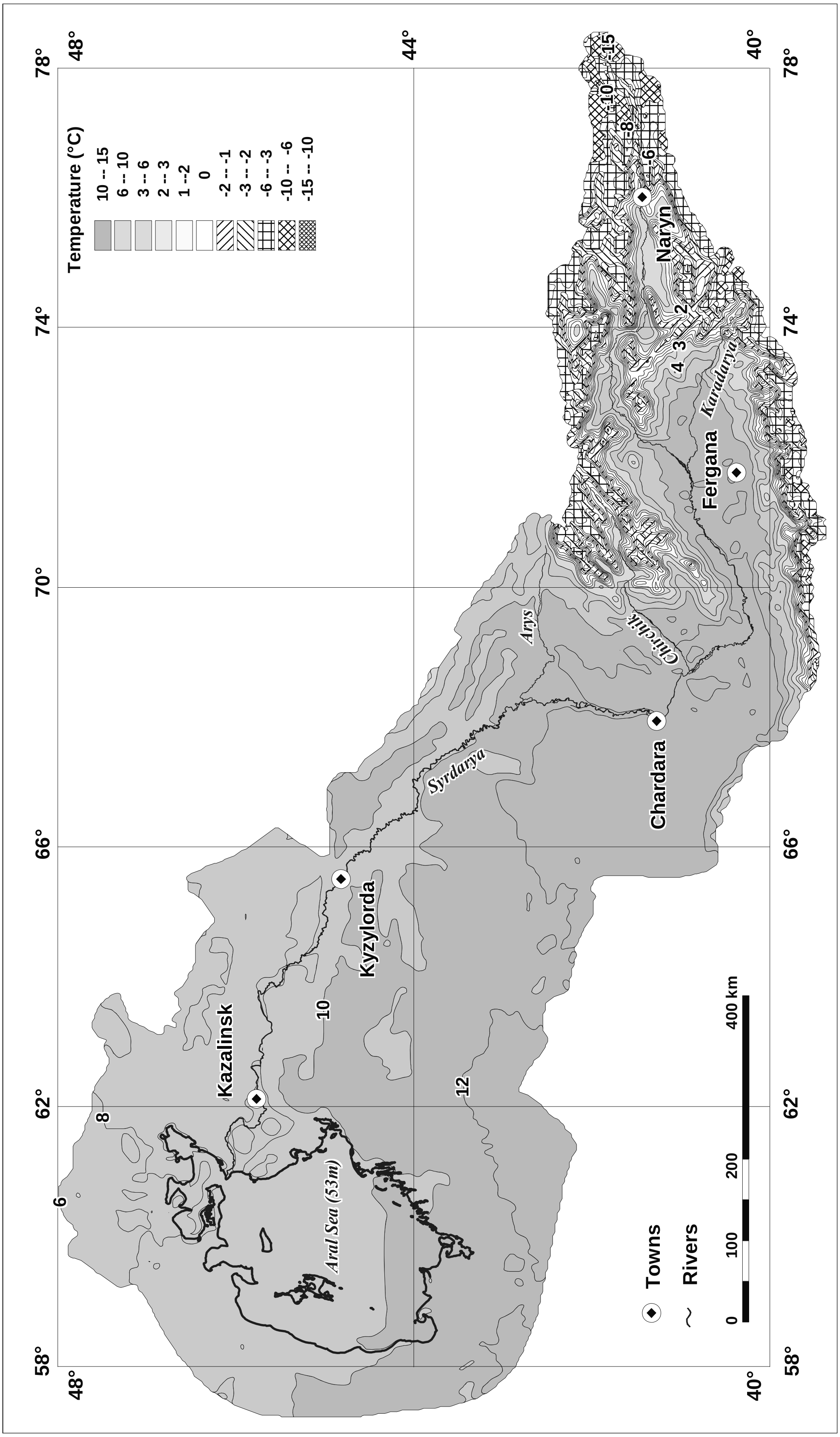

Figure 5. Map of average annual of air temperatures (°C) of Syrdarya River basin for the sixtieth years.

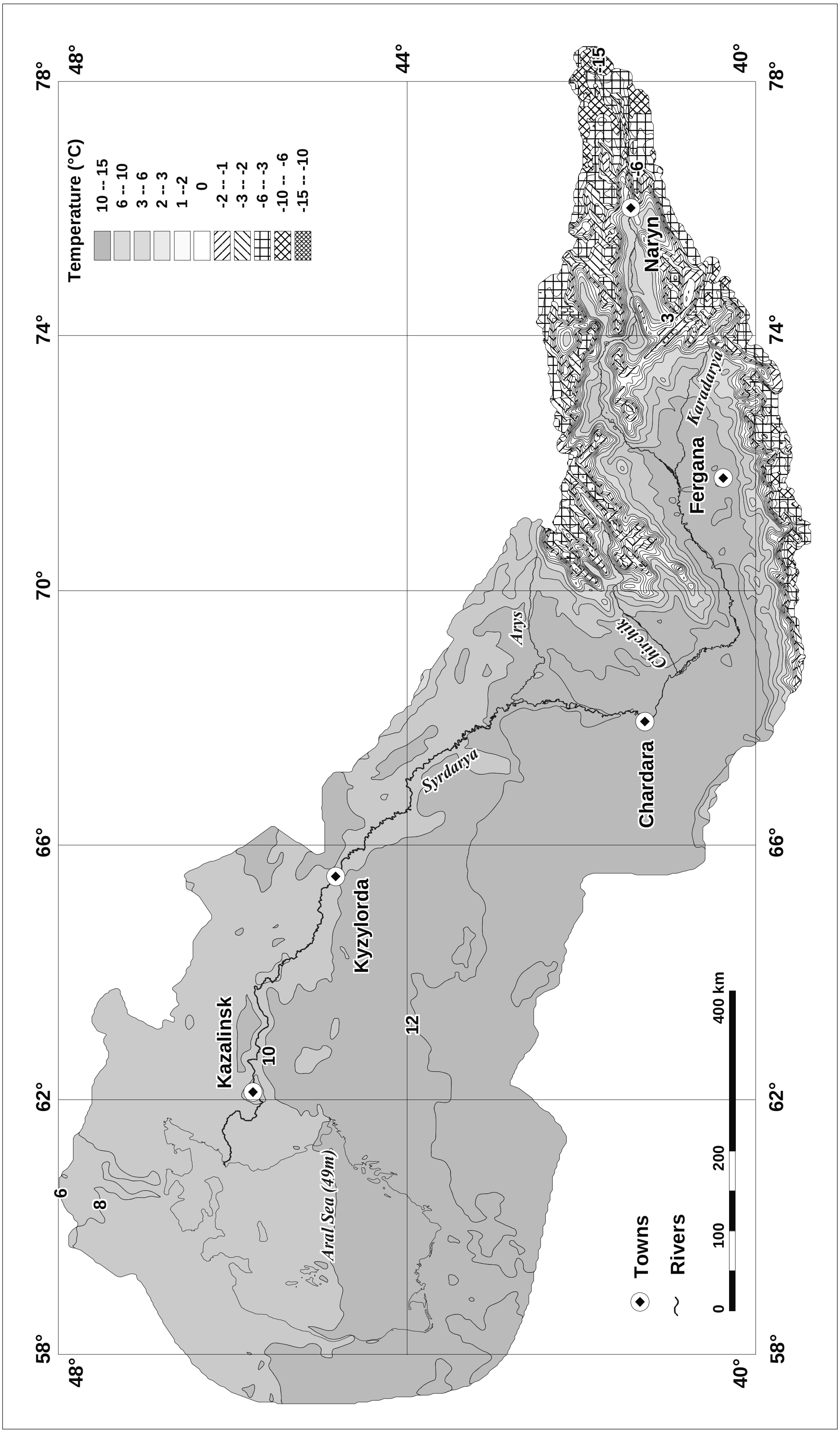

Figure 6. Map of average annual of air temperatures (°C) of Syrdarya River basin for the seventieth years.

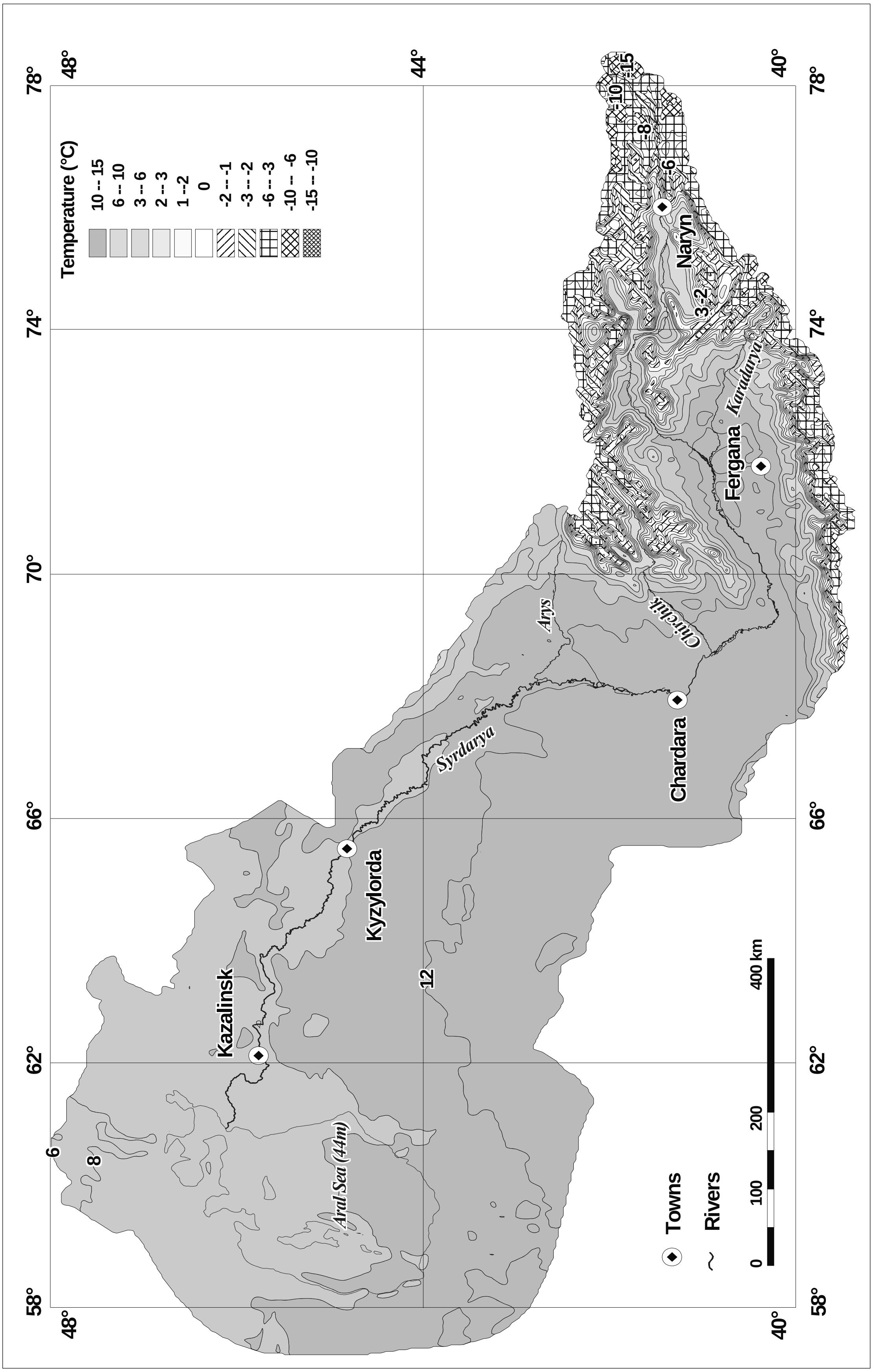

Figure 7. Map of average annual of air temperatures (°C) of Syrdarya River basin for the eightieth years.

On change to effect of water surface on a thermal regime there has come effect of the areas of development of solonchaks. In the spring and summer seasons air temperature above water surface of below surrounding temperature background, but an autumn season it is a little bit higher. It is superfluous humidified saline terrains in the spring and is little bit cooler than an environing background in the summer, and by the autumn they completely lose a humidifying and are indistinguishable in temperature field from surrounding background.

Variability of air temperature between decades

Features of changes for a thermal regime between decades are shown at the analysis of differential maps. Application of more detailed graduation of temperature fields allow distinctly to mark out aboriginal differences of temperature fields.

Over-all increase of level of average annual temperature field for a decade from 1970 till 1979 had heterogeneous character (Figure 8). In northern part of Syrdarya River basin and above aquatory of Aral Sea raise of average annual temperatures in limits 0.4 ÷ 1.5 °C for ten years was registered. South-western slopes of Karatau ridge, Fergansky valley and also surrounding mountain terrains of Western Tien-Shan, Turkestansky and Alaysky ridges, are characterized by relative lowering of temperature field in a range -0.4 ÷-0.8 °C.

In areas of Internal Tien-Shan raise of average annual air temperatures to 0.7 °C is observed.

In the period of 1980-1989 relative warming has got more homogeneous character and embraced whole Syrdarya River basin. Over-all raise of a level of average annual temperature field on 0.4 ÷ 0.8 °C concerning the sixtieth years specifies stabilization of regional warming (Figure 9). Level recession of Aral Sea to 44 m for twenty years was showed in change of temperature regime in a drying zone up to 0.5 ÷ 1.5 °C.

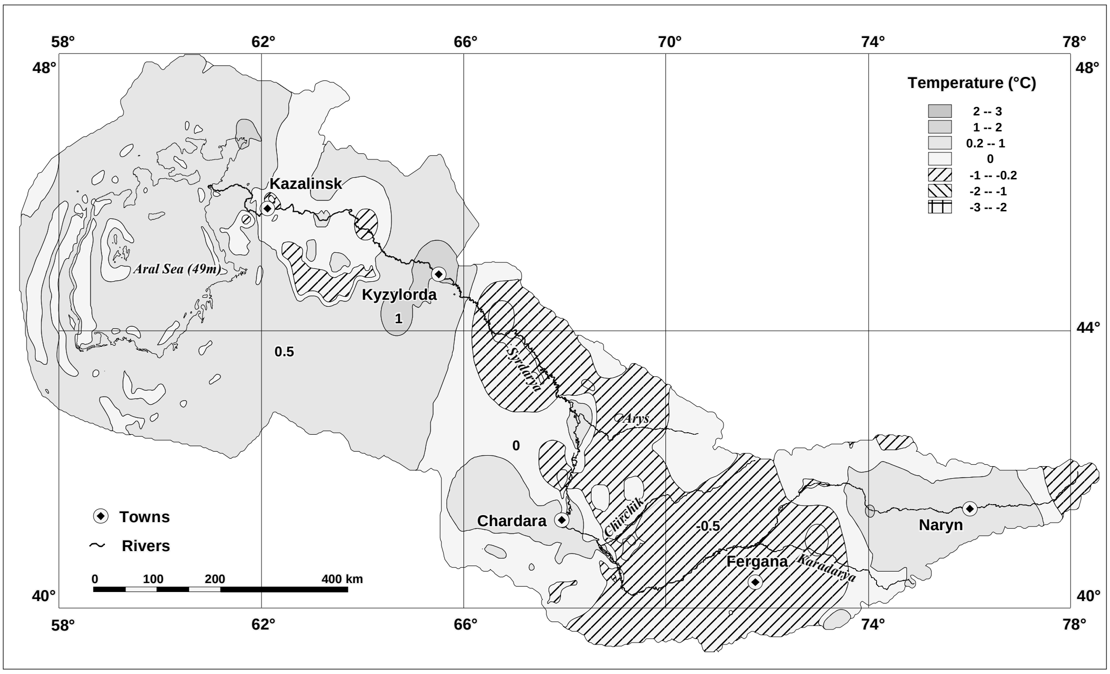

Figure 8. Map of differences between average annual of air temperatures (°C) of Syrdarya River basin for the seventieth and sixtieth years.

Changes of regional temperatures of air in the period from 1970 till 1989 years developed as follows:

- As a whole, the twentieth decade 1970 - 1989 years is characterized by regional raise of air temperatures on magnitude 0.3 ÷ 1.2 °C, including:
- for the seventieth years warming had fragmentary character and has mentioned in basic north-western and eastern parts of region while in the central part the relative cold snap was observed small on amplitude;
- for the eightieth years warming has amplified and embraced all terrain of Syrdarya River basin and Aral Sea;
- The basic contribution to regional warming was made with change of temperature background of a winter season;

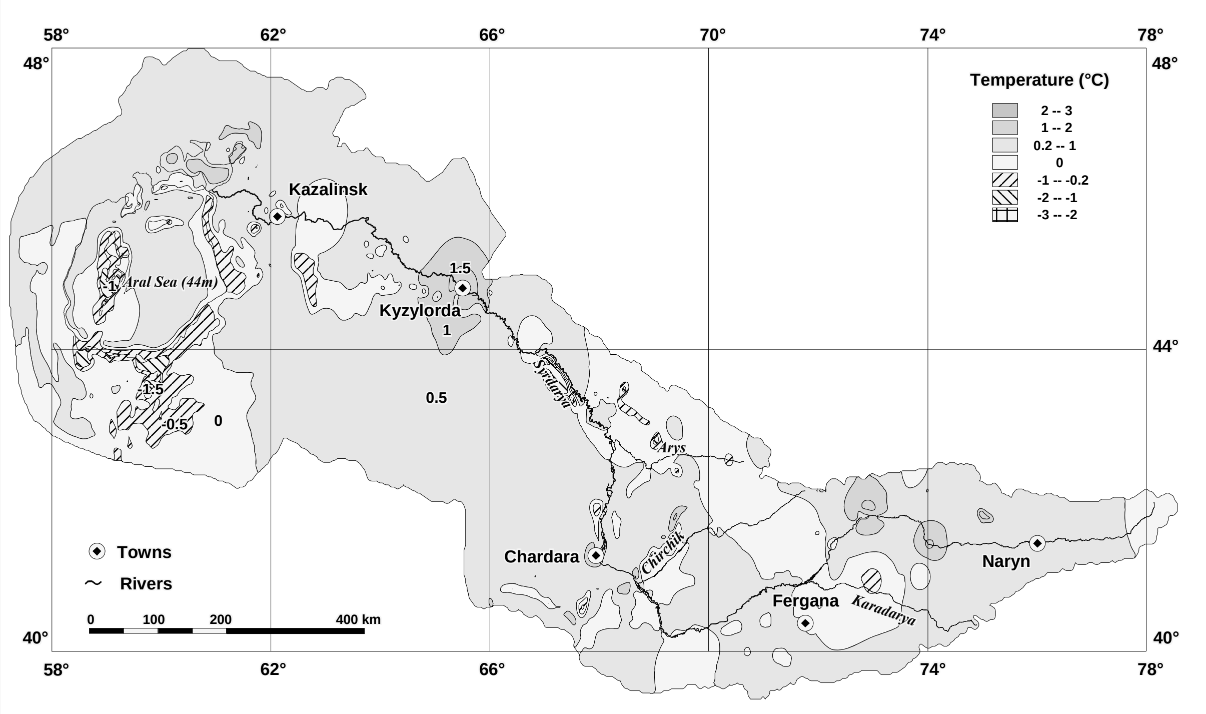

Figure 9. Map of differences between average annual of air temperatures (°C) of Syrdarya River basin for the eightieth and sixtieth years.

- Influence of anthropogenic activity on formation and change of a temperature regime were local character, is dated for large human settlements with the developed infrastructure, to the irrigated agricultural areas and rendered negligible effect on the over-all climatic status of Syrdarya River basin;
- The greatest influence of economic activities on an aboriginal climate was showed in area of Aral Sea and other water reservoirs in the period from 1965 till 1989. On a measure of decreasing of Aral Sea aquatory the temperature regime of dry land adjoining to it varied to the greater aridisation. Around again educated water reservoirs the aboriginal climate was softened. Range of influence of water surface on surrounding land does not exceed 10 ÷ 20 % from the dimensions of their aquatories.

Precipitations

The analysis of the causes of losses of the water resources being consequence of anthropogenic activity provides the count of share of climatic caused time variations of distribution of precipitations. The relative evaluation of changes of precipitations storage shows that in the seventieth – the eightieth years in Syrdarya River basin of precipitations fell out on 8.15 % and on 5.52 % accordingly less, than for previous period (Figure 10).

Total volume of precipitations for headstreams Syrdarya River and its main inflow - Naryn River in the period from 1970 until 1989 remained practically constant. Decreasing of precipitations amount in comparison with the sixtieth years is observed on the middle and the lower flow Syrdarya River.

Average precipitations on decades

By results of modelling for the season of the sixtieth years for Syrdarya River basin it is characterized by very wide range of a spacing of the sums of an average annual precipitations on terrain from 40 mm/year of arid plains and intermountain depressions up to 2000 mm/year in high mountain areas of Western Tien-Shan (Figure 11). Mountain terrains of Internal Tien-Shan, which are the main area of a inflow area for Naryn river, the largest inflow p. Syrdarya, gain on 600 ÷ 1000 mm/year of less precipitations, than other mountain areas. It is caused by shielding effect of the Fergansky crops, which contoured from the eastern Fergansky valley and has altitude 3500 ÷ 4500 m. above sea level. In the result, separate intramountain depressions of Internal Tien-Shan in its western range gain precipitations less, than in a zone of arid plains, up to 40 ÷ 120 mm/year. The windward High slopes of Western Tien-Shan is more east towards moisture-laden to air streams also work as a trap for a precipitations. Therefore in the given range the greatest are marked for all Syrdarya River basin average annual precipitations 1200 ÷ 1800 mm/year, and places up to 2000 mm/year. Aquatory of Aral Sea because of the lowered temperature regime (Figure 10) has more congenial conditions of a water condensation and consequently it is distinguished above an environing background the increased values of a precipitations 200 ÷ 300 mm/year.

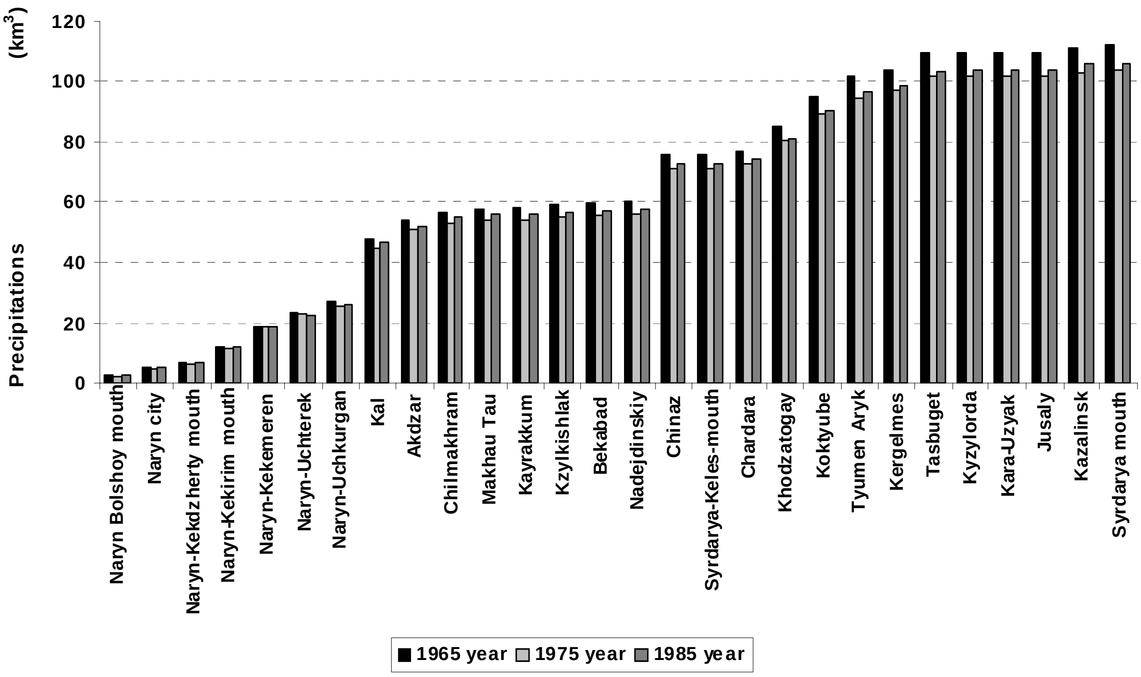

Figure 10. Changes of average annual precipitations on hydroposts Syrdarya River on decades.

The additional description of precipitations storage regime for the Aral basin down to the sixth decade of the twentieth century can be found in publications [1, 2, 3, 4, 5].

Occurred in 1970 – 1979 years lowering of intensity precipitations storage in Syrdarya River basin was distributed on terrain non-uniform (Figure 12). On a background of over-all decreasing of amount of an average annual precipitations on -50 ÷ -250 mm/year in comparison with an average level of the sixtieth years in a south-western part of Internal Tien-Shan there was an augmentation of a precipitations on 50 ÷ 70 mm/year. Local raises similar to them precipitations storage are marked and in Western Tien-Shan. High altitude territories variability of precipitations and the big ranges of values do not allow estimating completely changes precipitations storage for a decade at direct comparison of results of modelling. The detailed analysis of changes realized in the paragraph **Variability of precipitations between decades**.

Feature of a regime precipitations storage for the period 1980 – 1989 years shows in over-all small lowering a level of an average annual precipitations in comparison with the sixtieth years essential decreasing of their amount above aquatory of Aral Sea up to -100 mm/year is registered (Figure 13). It is on 150 mm/year less than average amount of the annual precipitations, which is falling out in this area in the sixtieth years. Besides high local variability of a regime precipitations storage in mountain areas is observed. In boundaries the same mountain ridges the areas as with be relative increased precipitations amount on 50 ÷ 300 mm/year, and with be relative lowered values on -100 ÷ -600 mm/year are revealed in comparison with the sixtieth years. High territorial variability of distribution of precipitations and big gradients complicate a qualitative assessment by results of modelling. Therefore, the detailed analysis of time changes in the paragraph **Variability of precipitations between decades** is realized.

Variability of precipitations between decades

In the seventieth years on the bulk of the area of Syrdarya River basin decreasing of average annual precipitations is observed (Figure 14) in comparison with the sixtieth years. For ten years of Syrdarya River basin the average precipitations amount has decreased on -10 ÷ -50 mm/year in a flat part and in mountain areas on -25 ÷ -130 mm/year. The most essential decrease of annual precipitations is marked in Talassky, and Fergansky ridges and places on southern slopes of crops Terskey Ala Tau. Here it was changes in limits from -200 up to -650 mm/year. In mountain areas of Western Tien-Shan, on joint Talassky and Kyrgyzsky ridges and a south-western part of Internal Tien-Shan the local areas with the increased values of changes of precipitations of the seventieth years 10 ÷ 700 mm/year are founded.

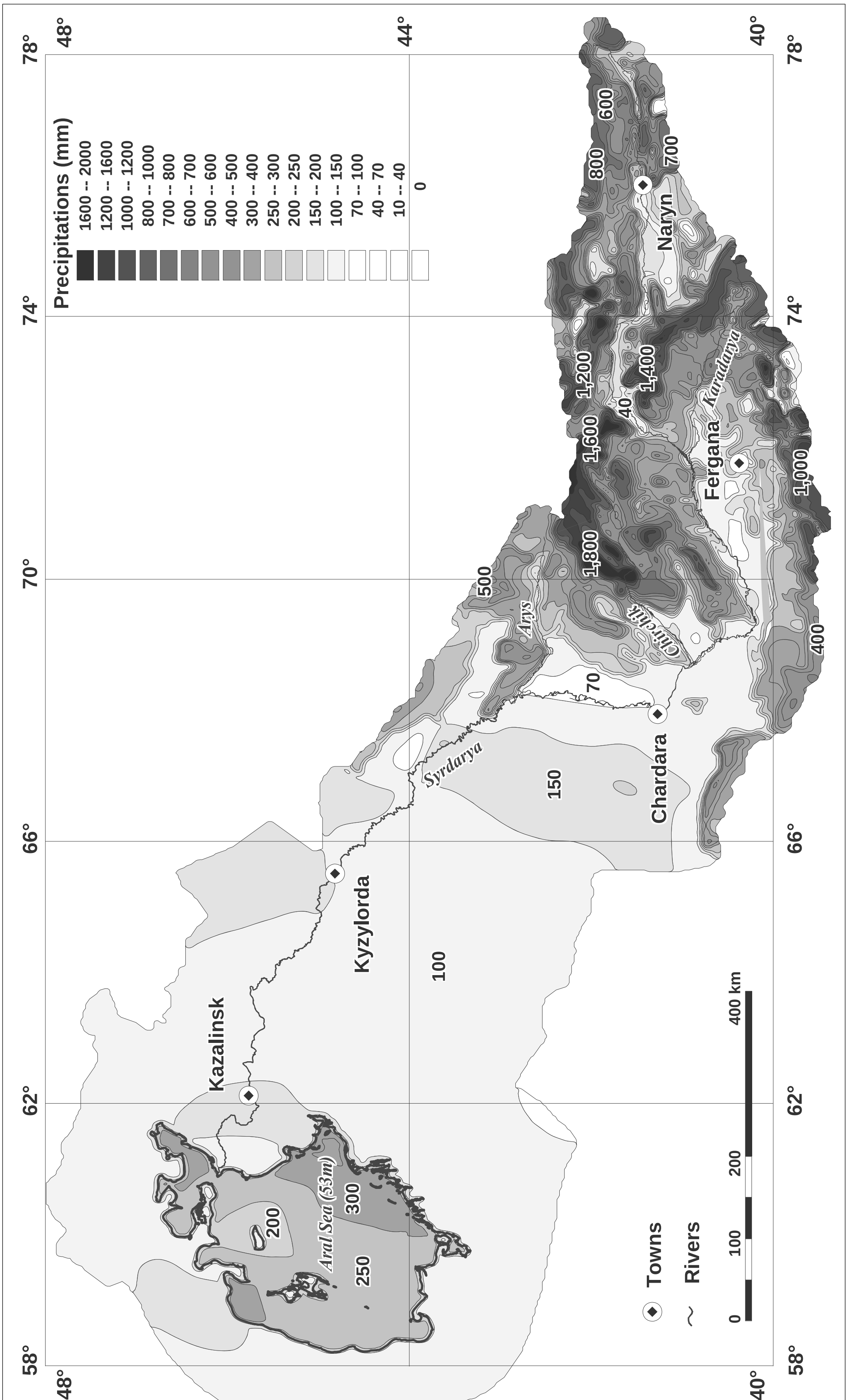

Figure 11. Map of average annual precipitations (mm) of Syrdarya River basin for the sixtieth years.

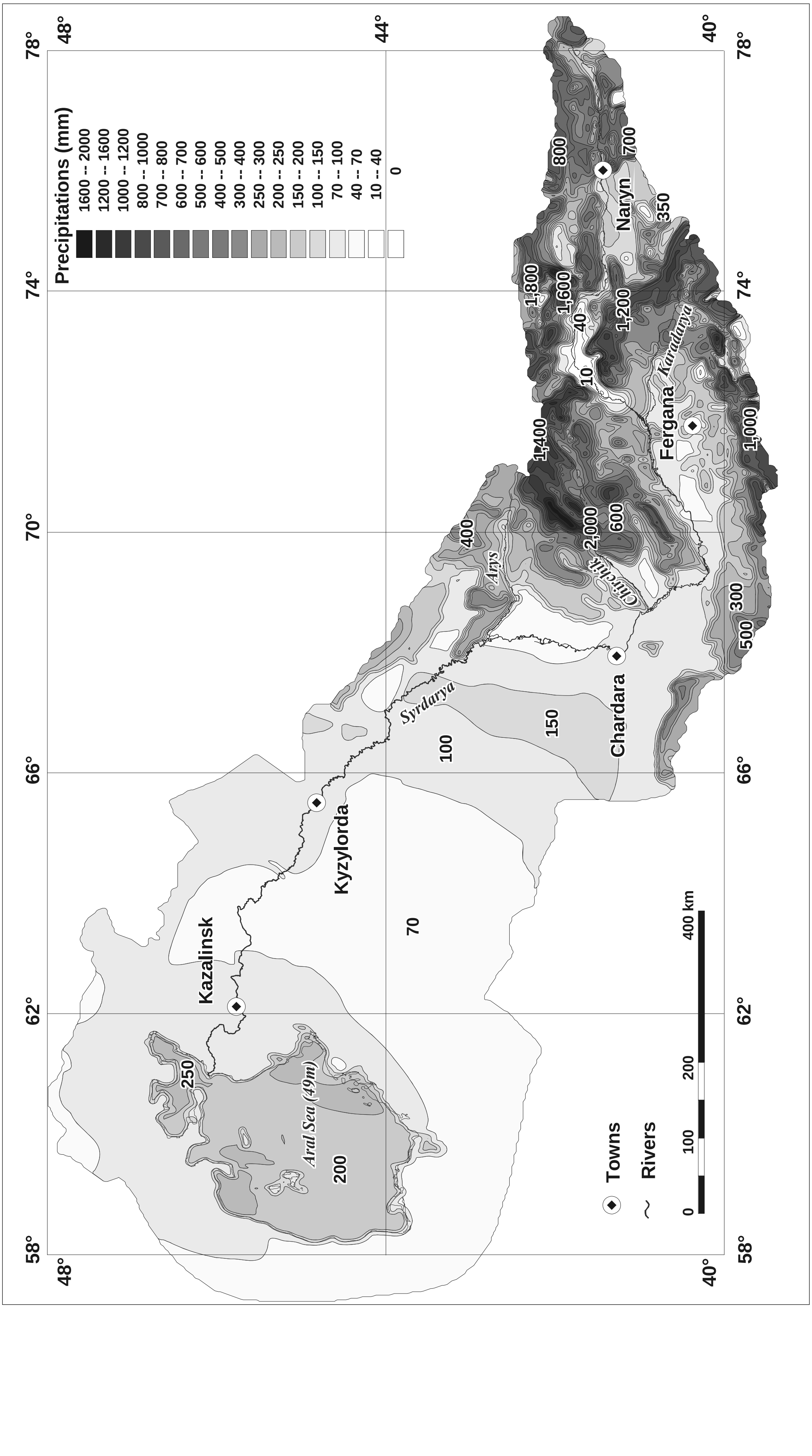

Figure 12. Map of average annual precipitations (mm) of Syrdarya River basin for the seventieth years.

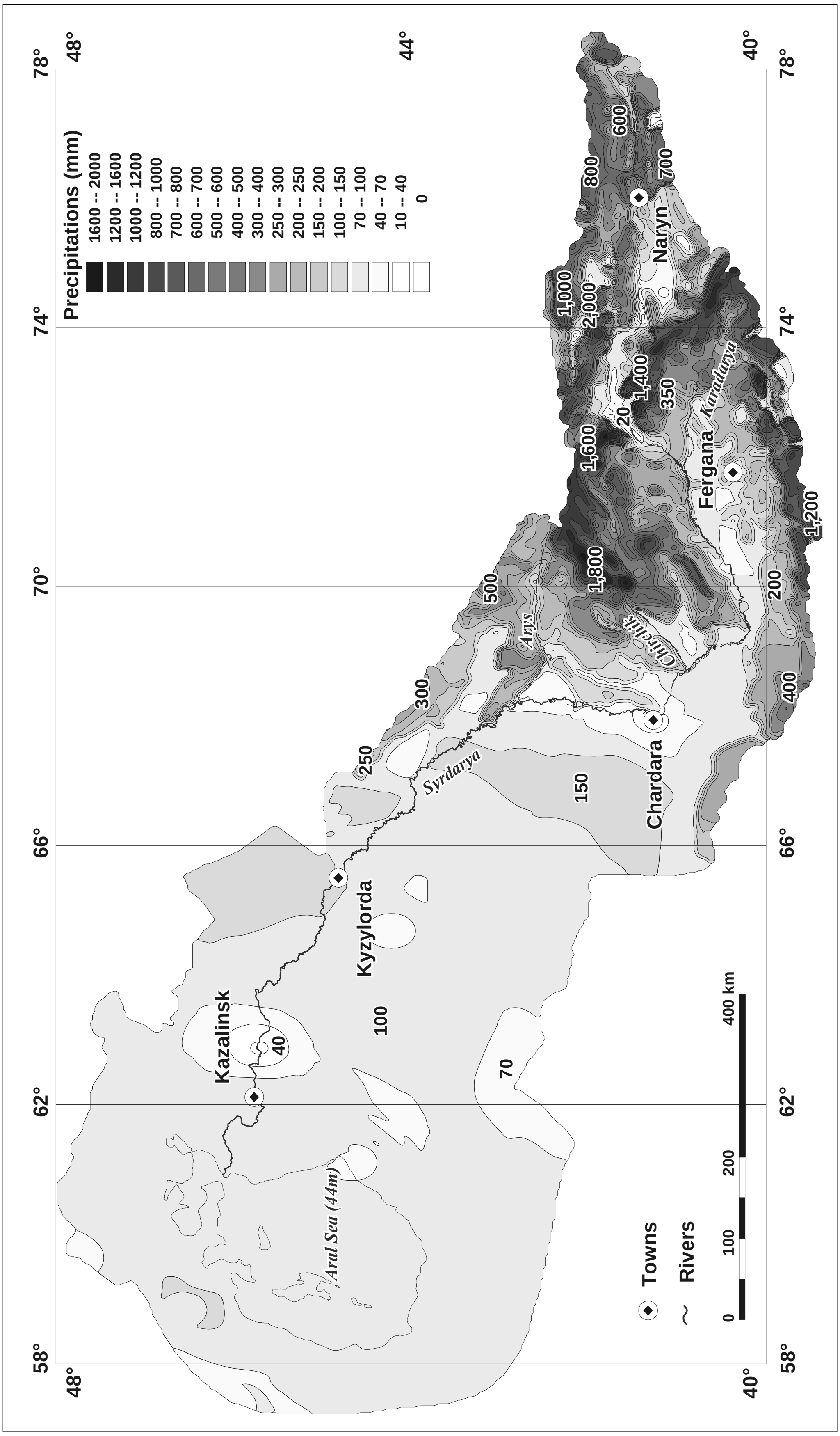

Figure 13 .Map of average annual precipitations (mm) of Syrdarya River basin for the eightieth years.

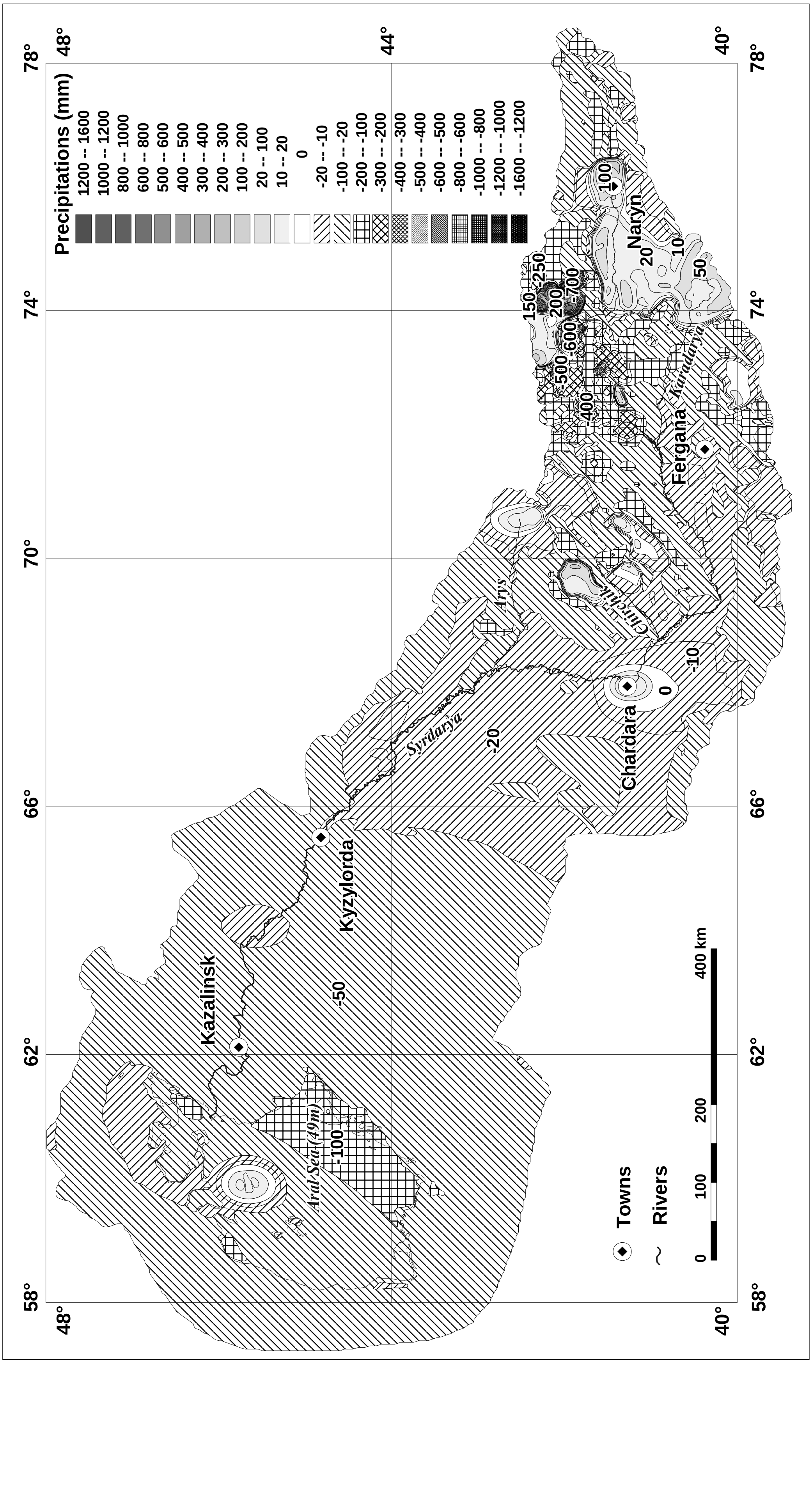

Figure 14. Map of differences between average annual precipitations (mm) of Syrdarya River basin of the seventieth and sixtieth years.

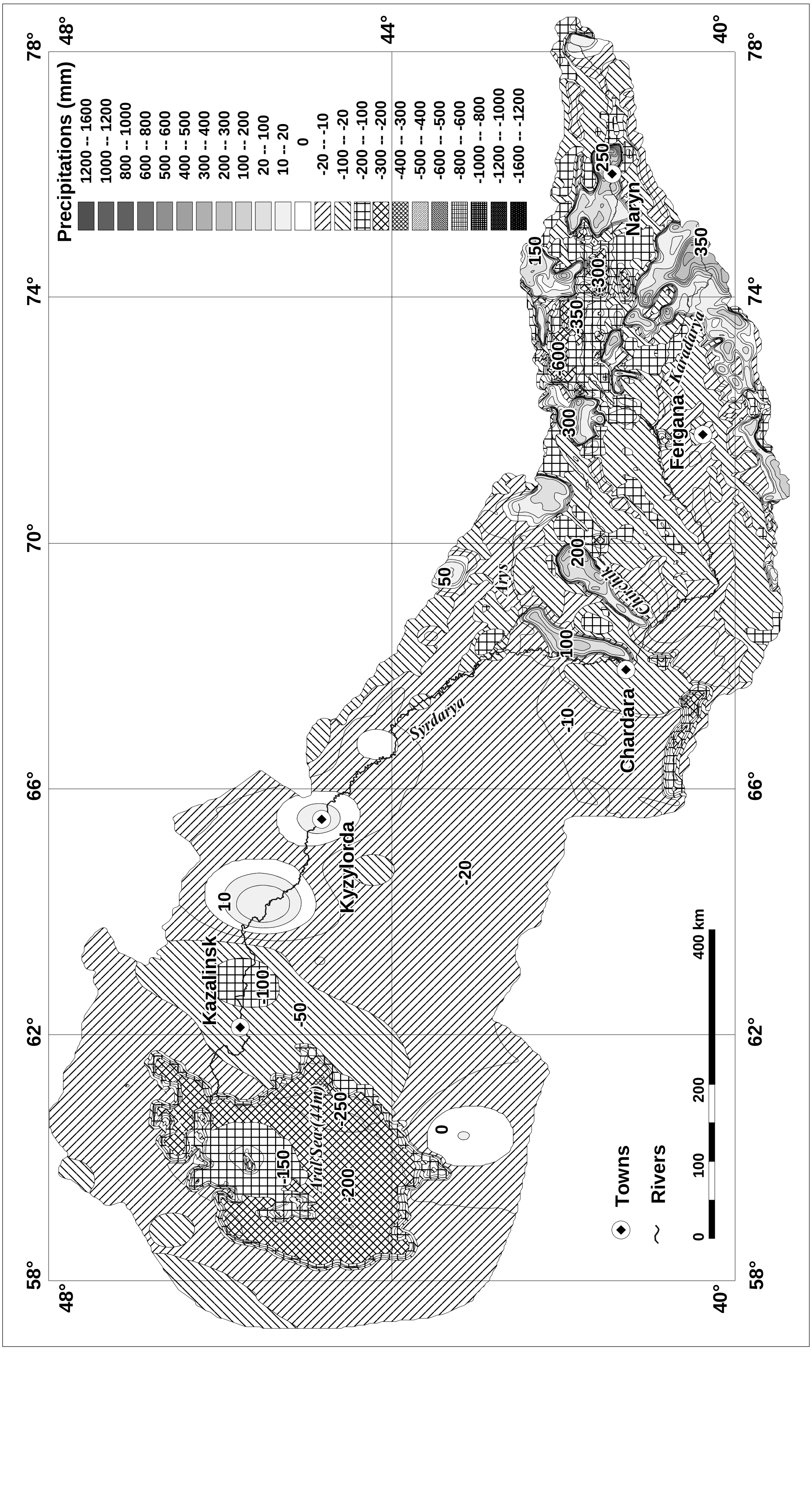

Figure 15. Map of differences between average annual precipitations (mm) of Syrdarya River basin of the eightieth and sixtieth years.

In the period from 1960 until 1989 years, the rearrangement of regional circulation, which has begun in the seventieth years, was stabilized also a regime of precipitations storage has got resistant character (Figure 15). It has found the reflectance in a field of change of precipitations with well contoured ranges of changes and high gradients in conversion zones. Decreasing of precipitations in a flat territory changes was in limits -5 ÷ -50 mm/year, for low-mountainous zones -50 ÷ -150 mm/year and for middle-high-mountainous zone of Internal Tien-Shan -200 ÷ -600 mm/year. In ranges of the increased humidifying Western Tien-Shan and the Fergansky ridge of the central part of Syrdarya River basin, Talassky and Kyrgyzsky ridges in north-east, Turkestansky and Alaysky ridges of the marginal south terrain the precipitations amount has increased on 50 ÷ 350 mm/year. For twenty years the precipitations for aquatory of Aral Sea has essentially decreased on -150 ÷ -250 mm/year.

Changes regional of precipitations storage in the seventieth - the eightieth years educed as follows:

- Over-all regional decrease of precipitations amount in the season 1970 – 1989 years allows to characterize it as moderately droughty;
- Conversion of regional circulation of an atmosphere, which result was decrease of average precipitations amount on decades in region, educed in a direction of total decreasing of precipitations for flat and low mountainous zones and particulate augmentation of their amount in middle and high-mountainous altitudinal zones;
- Stabilization of process of change such as atmospheric circulation has taken place in the eightieth years;
- The minimum of precipitations for the seventieth years had deficiency of 8.15 % from a level of the sixtieth years;
- In the eightieth years deficiency of precipitations has made 5.52 % from a level of the sixtieth years.

Evaporation

Evaporation is the main amounting account part of a water balance which in basic depends on the thermal status, atmospheric humidity and is limited by terrains precipitations storage regime. Evaporation is most sensitively reacting to changes of economic activities in regions with an arid climate from all investigated climatic parameters. An evaluation of integrated values of evaporation in Syrdarya River basin on decades 1970 – 1979 years and 1980 – 1989 years shows that it has increased in the seventieth years till 6.13 %, and in the eightieth years till 9.43 % from level of the sixtieth years (Figure 16).

Annual evaporation of the period 1970 – 1979 years for eastern part of Syrdarya River basin is not enough distinguishable from values of evaporation of the period up to 1969 years (Figure 18). Changes of quantity indicators of average annual evaporation in this part of basin basically are caused by change of regime precipitation storage in mountain areas, building of new reservoirs in zones of economic development and have restricted distribution. The most significant changes of evaporation regime have taken place in a north-eastern part of Syrdarya River basin at the turn of Talassky and Kyrgyzsky ridges. Here average annual evaporation has values 300 ÷ 400 mm/year. In this mountain area, on again built Toktogulsky water reservoir and evaporation for its area has increased up to 800 mm/year. Other potent source of evaporation – shallow Arnasaysky water reservoir has high intensity of average annual evaporation 1400 ÷ 1600 mm/year. In the central and north-western parts of region conversion of a spacing of evaporation was the result of a flooding of the new agricultural areas in Kazalinsk, Kyzylordinsky, Dzusalinsky and Shieli-Dzanakorgansky irrigation fields and also as a result of decreasing of the area of Aral Sea. Changes of average annual evaporation in new irrigated terrains had fractional character, which are introduced, as a rule, families of small areas of the increased values of evaporation by intensity 200 ÷ 250 mm/year. In the seventieth years, Aral Sea was in zone of small regional increase of air temperatures (Figure 8). In this decade, the level of Aral Sea has gone down on the average up to 44 m. The precipitations amount for its aquatory has decreased (Figure 14). The assemblage of these processes has become the cause of raise of evaporation from a surface of Aral Sea. The range of average annual evaporation 1200 mm/year in the seventieth year was passed round by magnitude the north further, than in the sixtieth years. At the same time, in a zone of a drained bottom evaporation has strongly decreased because of disappearance here free water.

The climatic changes, which have occurred for twenty flying from 1960 until 1989 years, were not reflected a little appreciably in an over-all regime the climatic caused average annual evaporation of Syrdarya River basin (Figure 19). Exclusion is the north-western part of Internal Tien-Shan, where in intermountain valleys of Naryn River basin and its inflows is observed small lowering evaporation with mean 100 ÷ 200 mm/year and for mountain ridges 250 ÷ 400 mm/year. Serious changes of an annual regime of evaporation in the eightieth years have taken place on the irrigated agricultural areas in the lower flow Syrdarya River. For this period is necessary maximum of intensity of economic development Kazalinsky, Kyzylordinsky, Dzusalinsky and Shieli-Dzanakorgansky areas of irrigation. In such terrains the essential augmentation of evaporation is observed. In the eightieth years in ranges of diffusion anthropogenic changed landscapes mean of evaporation change over a wide range 250 ÷ 800 mm/year. Common regional increase of air temperature in the eightieth years (Figure 9) promoted augmentation of average annual evaporation from a surface of water reservoirs in mountain areas of basin. For water Toktogulsky reservoir its magnitude is equal 1000. Evaporation in drained zone of Aral Sea has decreased up to 200 mm/year while it is strong the sea aquatory evaporated on the average 1200 mm/year.

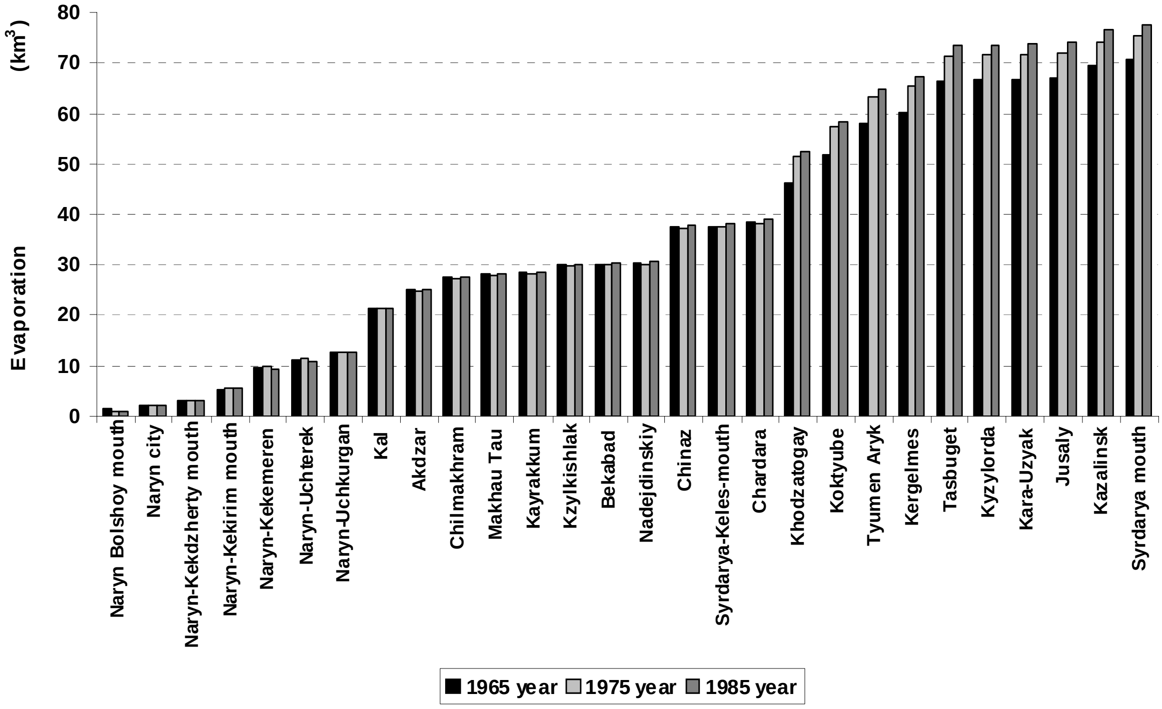

Figure 16. Changes of annual evaporation on hydroposts Syrdarya River on decades.

Variability of evaporation between decades

The detailed analysis occurred in the season 1960 – 1979 years of changes of a regime of annual evaporation in Syrdarya River basin shows that three factors influencing spacing and magnitudes of evaporation differently prove in dependence on developed conditions – thermal regime, regime precipitation storage and anthropogenic press on natural habitat. On a suppressing part of a dry land with an arid climate in the capacity of a primary factor influencing between decade's change of average annual evaporation variability between decade's of regime precipitations storage is. Decreasing in the seventieth years of amount of a falling out precipitations in comparison with a level of the sixtieth years (Figure 14) has predetermined decrease of evaporation rate on the average on -10 ÷ -50 mm/year, and in intermountain depressions of north-western area of Internal Tien-Shan most injured of a drought up to -100 ÷ -250 mm/year. At the same time, increase of precipitations amount in the central range of Internal Tien-Shan in a combination to increase of a regional temperature background promoted an intensification of average annual evaporation on 10 ÷ 20 mm/year. As against the climatic caused landscapes, evaporation with intrazonal and anthropogenic changed landscapes in the greater extent is determined by change of water requirement and a thermal regime. Despite of raise of a regional temperature background in the seventieth years (Figure 8), in range of diffusion of silted intrazonal landscapes of delta Syrdarya River between decade's decreases of magnitude of average annual evaporation on-10 ÷-20 mm/year was observed. Within a decade, natural inundated landscapes have kept a regime of evaporation by the constant season in comparison from the sixtieth years. In zones of development of anthropogenic landscapes – new irrigational nets and irrigated agricultural lands, there were significant changes of a regime of evaporation. All again mastered in the season 1970 – 1979 years agricultural terrains in Kazalinsky, Dzusalinsky, Kyzylordinsky and Shieli-Dzanakorgansky areas of an irrigation are characterized by raise of annual evaporation on the average on 50 ÷ 150 mm/year in comparison with a level of the sixtieth years.

The strongest changes of a regime of evaporation for ten years have taken place in areas for created of new water reservoirs and in a zone of a drained Aral Sea bottom. In middle mountainous zone in area of located of Toktogulsky water reservoir average annual evaporation has increased on 600 ÷ 800 mm/year in comparison with a level of the sixtieth years. Arnasaysky water reservoir, which located on plain of southern part of Syrdarya River basin, has increased intensity of annual evaporation for 1400 mm/year. Old large water reservoirs – Chardarinsky and Kayrakkumsky, for ten years have increased a level of average annual evaporation on 20 ÷ 50 mm/year. Change of a regime of evaporation of Aral Sea was affected with decreasing of the area of its aquatory and regional raise of a temperature background. The assemblage of these factors has become the cause of over-all between decade's raise of average annual evaporation on 20 ÷ 50 mm/year, and in places of education of new shoal waters on 200 ÷ 700 mm/year. In eastern and southern zones of a drained bottom of Aral Sea in the seventieth years strong level recession of evaporation is observed on -350 ÷ -1000 mm/year.

Changes of annual evaporation regime of Syrdarya River basin for the period 1960 – 1989 years have the fragmentary and limited spatial distribution (Figure 21). For the overwhelming majority climatic the caused landscapes the mode of annual evaporation of region of the eightieth years appeared is practically indistinguishable a similar mode of evaporation of the sixtieth years. Insignificant decreasing of intensity of evaporation on -10 ÷ -20 mm/year for twenty years is marked in middle-mountainous zone of the western Tien-Shan and a Turkestansky ridge. Middle-mountainous depressions of the western part of Internal Tien-Shan are characterized by relative decreasing by a level of average evaporation for the given period on -50 ÷ -100 mm/year. In the central part of Internal Tien-Shan is marked a small area of relative increase of annual evaporation on 20 ÷ 50 mm/year in comparison with the period up to the end of the sixtieth years. On a background of absence of changes of average annual evaporation on plains with natural ultraarid landscapes areas of change of evaporation in zones of agricultural activity which reason was the maximal intensification of water use for needs of irrigated agriculture in the eightieth years more contrast are marked. For twenty years, all irrigated agriculture areas of the lower flow of Syrdarya River – Kazalinsky, Dzusalinsky, Kyzylordinsky, Shieli-Dzanakorgansky and Chardarinsky Turkestansky and Bayrkum-Chardarinsky are distinguished in a field of changes of annual evaporation as compact families of local relative increases of evaporation on the average on 20 ÷ 150 mm/year, and places up to 300 ÷ 400 mm/year. For twenty years from 1960 until 1989 the strongest changes of a mode of evaporation have taken place in areas of education of new reservoirs and in a zone of Aral Sea drained bottom. For middle-mountainous Toktogulsky reservoir annual evaporation has increased by 800 mm/year in comparison with a level of the sixtieth years. For flat southern part of Syrdarya River basin for Arnasaysky reservoir is observed relative increase of annual evaporation on 1200 mm/year. Old water basins – Chardarinsky and Kayrakkumsky, for twenty years have increased a level of annual evaporation on 50 ÷ 100 mm/year. Change of a mode of evaporation of Aral Sea was affected with decreasing of the area of its water area on a background of total increase of regional air temperatures for the eightieth years. Set of these factors caused the general increase of average annual evaporation on 20 ÷ 50 mm/year for the period 1970 – 1989 years and in places of created of new shoalinesses on 200 ÷ 250 mm/year. For an extensive zone of the drained bottom of Aral Sea in the eightieth years strong decrease in a level of evaporation is observed on -600 ÷ -1200 mm/year.

Changes of regional evaporation in the season with 1969 on 1989 years educed as follows:

- Intra annual distribution of evaporation for the normative period shows:
  - on plains and in low mountain an altitudinal zone of a ultraarid climatic zone the maximum evaporation from a surface of a dry matter is limited by quantity(amount) of a falling out precipitations and consequently it is dated for the most humidified spring and autumn seasons;
  - in middle mountainous zone with semi-humid and humid types of landscapes, with a spring-and-summer maximum precipitations storage the season of intensive evaporation is extended due to inclusion in it of a summer season;
  - in a high-mountainous zone the season of the maximum evaporation is limited by a thermal regime and therefore restricted only by a summer season.
- The season 1970 – 1989 years is characterized by over-all raise of evaporation in the lower flow Syrdarya River and above aquatory of Aral Sea;
- The causes of increase of evaporation were:
  - regional raise of air temperatures;
  - appearance in the seventieth years in an southern part of basin of new shallow water reservoirs and shallows of Aral sea;
  - expansion of the areas of an irrigation farming mainly under water consumption agricultural crops – cotton and rice;
  - construction of new irrigational nets on old technologies.

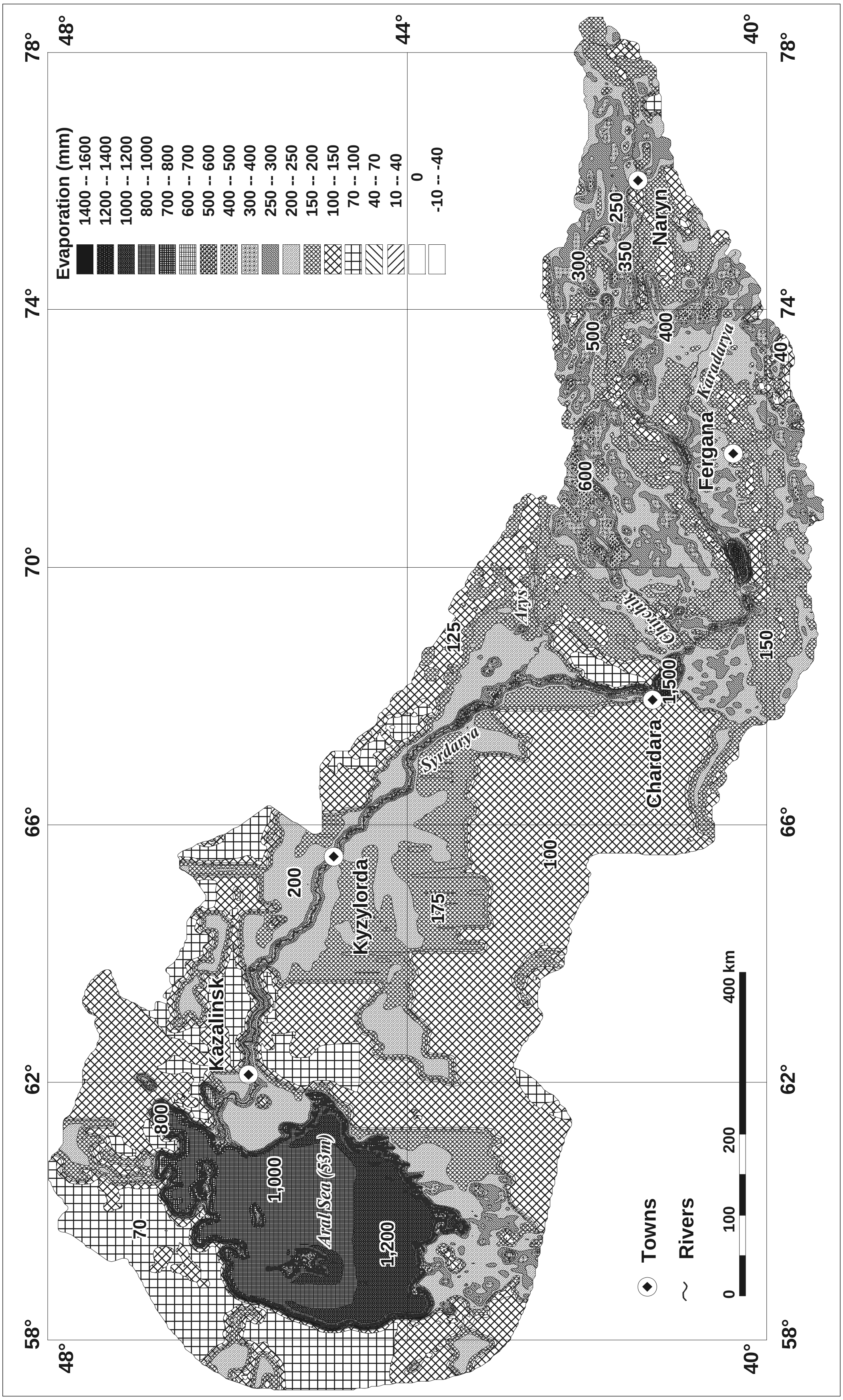

Figure 17. Map of average annual evaporation (mm) of Syrdarya River basin for the sixtieth years.

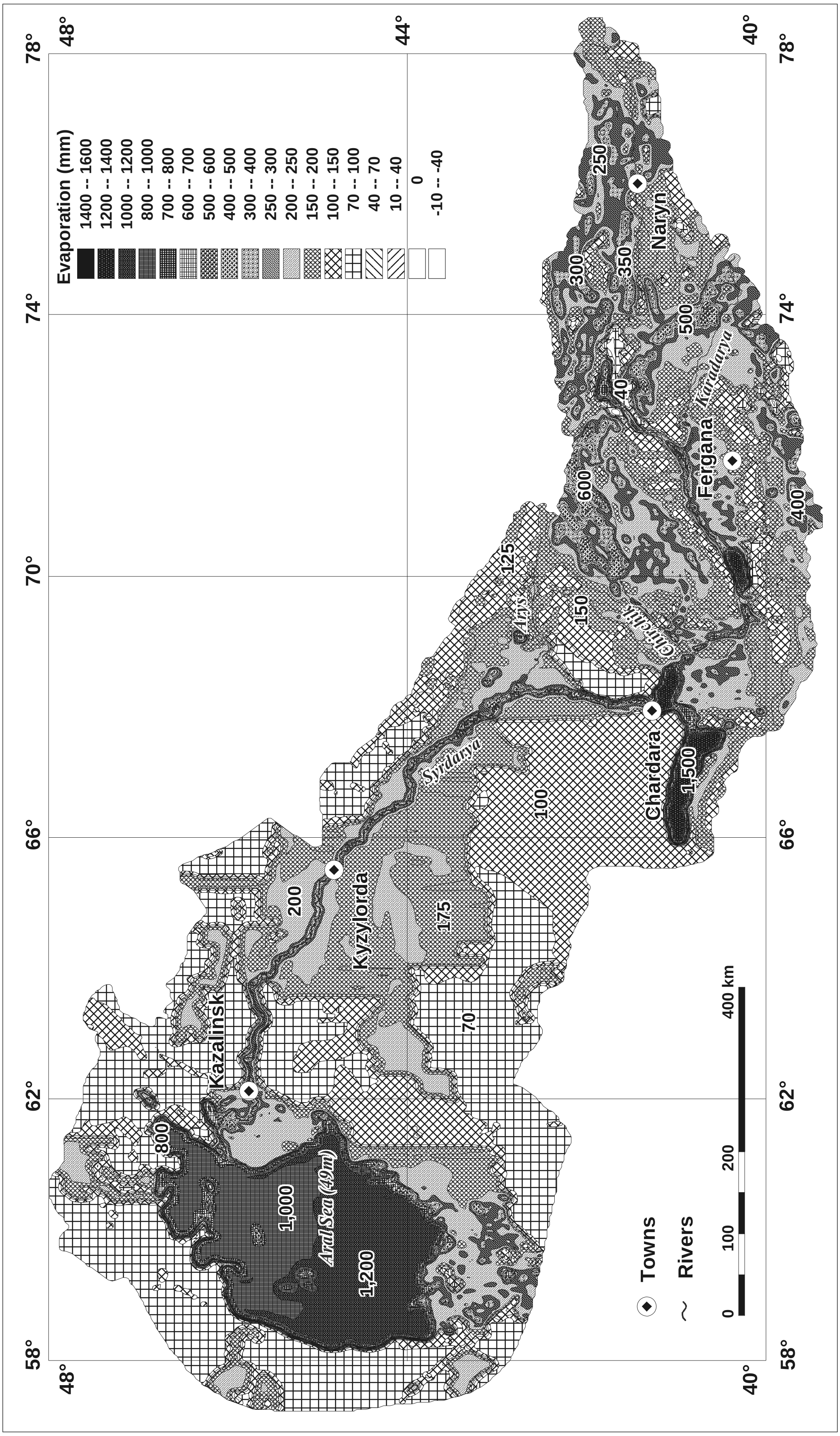

Figure 18. Map of average annual evaporation (mm) of Syrdarya River basin for the seventieth years.

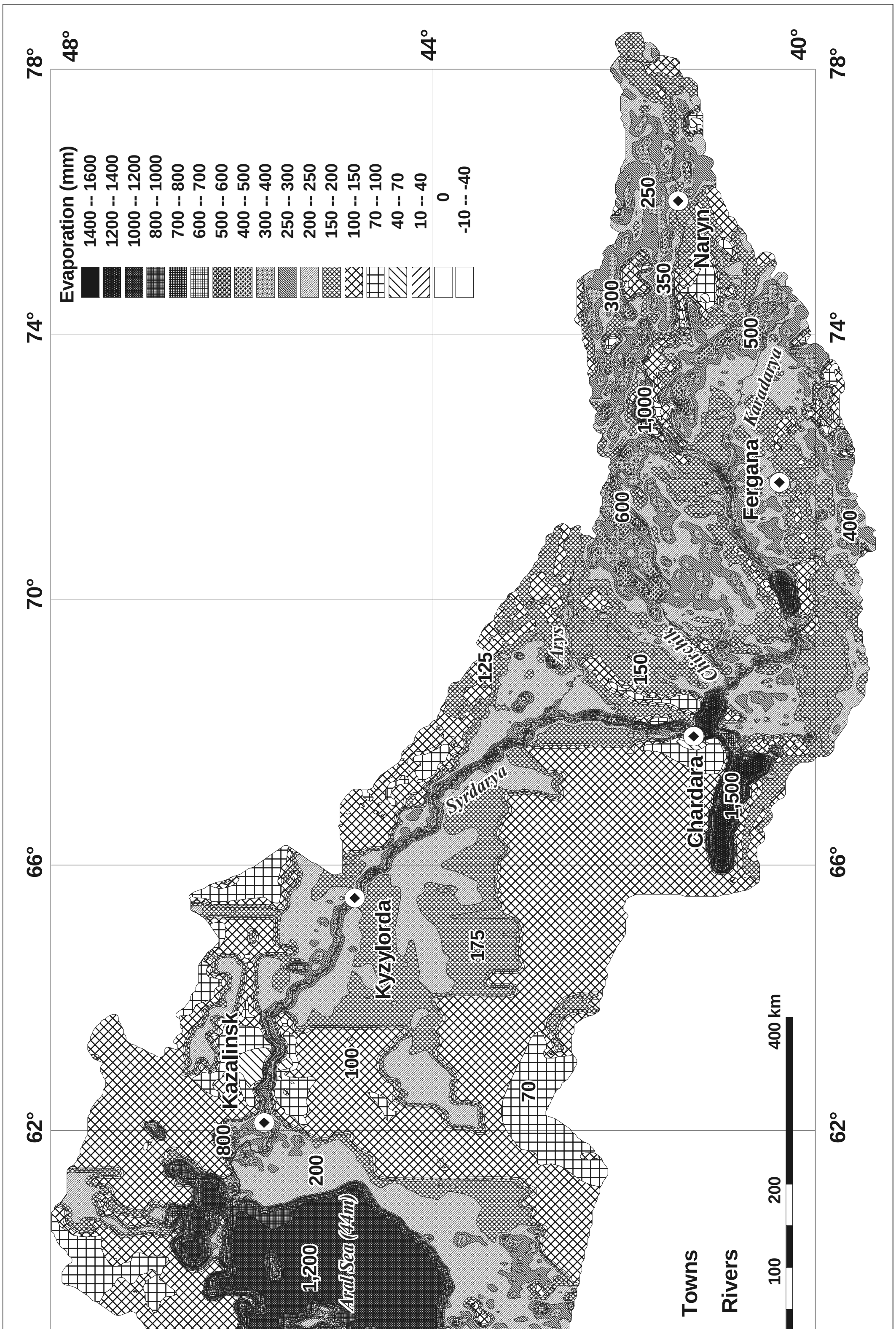

Figure 19. Map of average annual evaporation (mm) of Syrdarya River basin for the eightieth years.

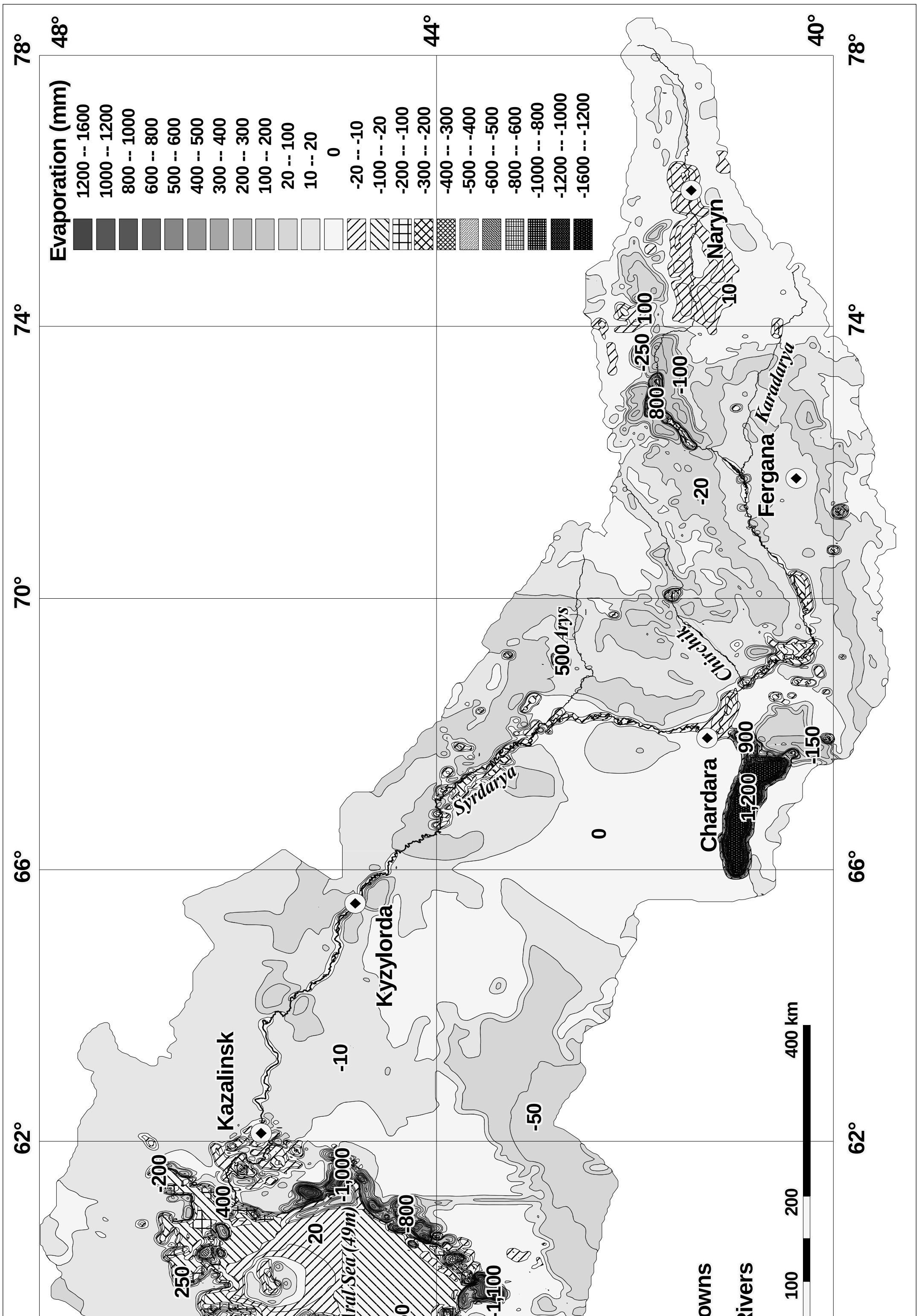

Figure 20. Map of differences between average annual evaporation (mm) of Syrdarya River basin for the seventieth and sixtieth years.

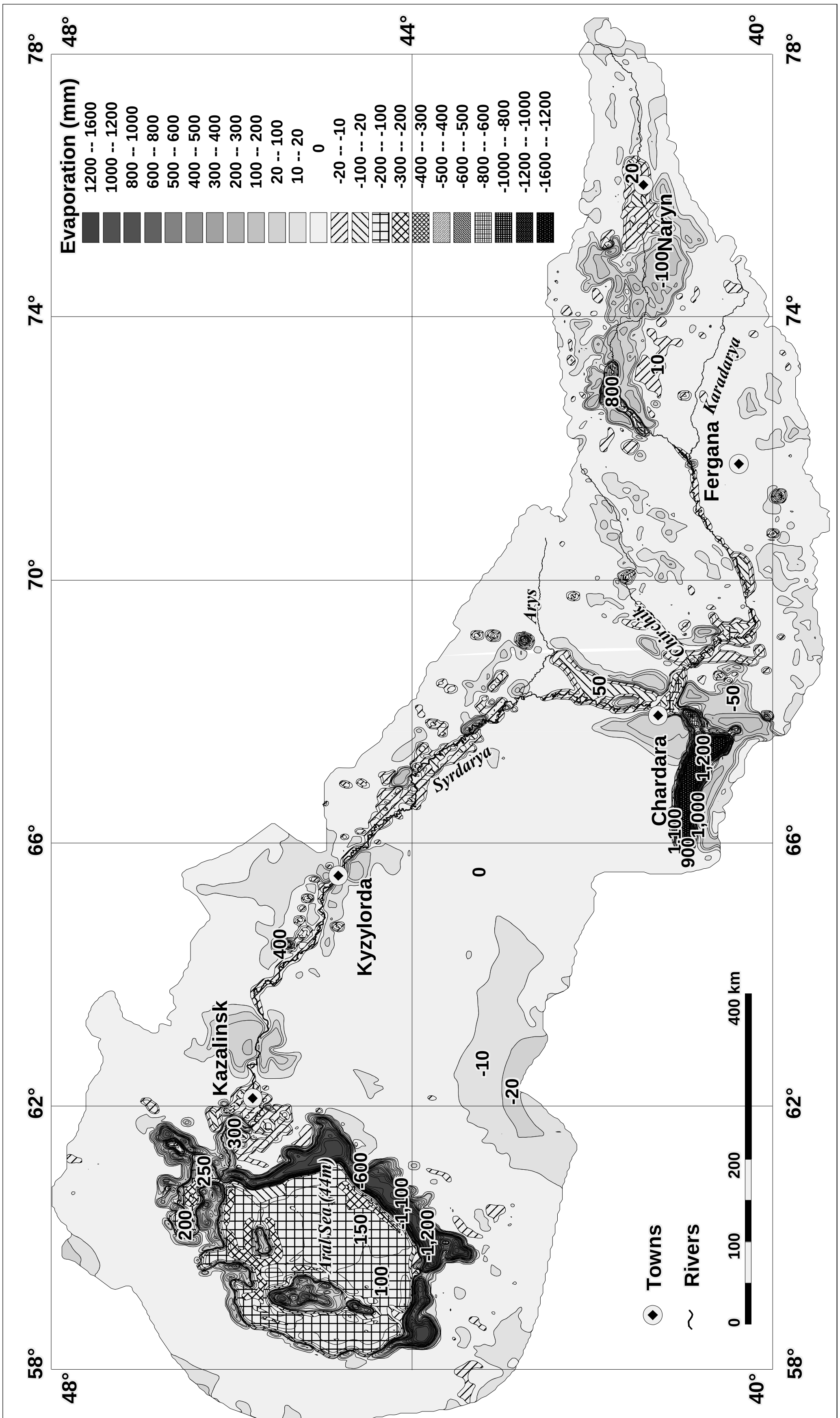

Figure 21. Map of differences between average annual evaporation (mm) of Syrdarya River basin for the eightieth and sixtieth years.

Water balance

The water balance is a parameter reflecting a ratio of a precipitations and evaporation and having the important practical value for economic activities. The analysis of time changes of a water balance in Syrdarya River basin for the periods 1970 – 1979 years and 1980 – 1989 years shows that it has decreased accordingly for -35.7 % and on -34.6 % from a base level of the sixtieth years (Figure 22).

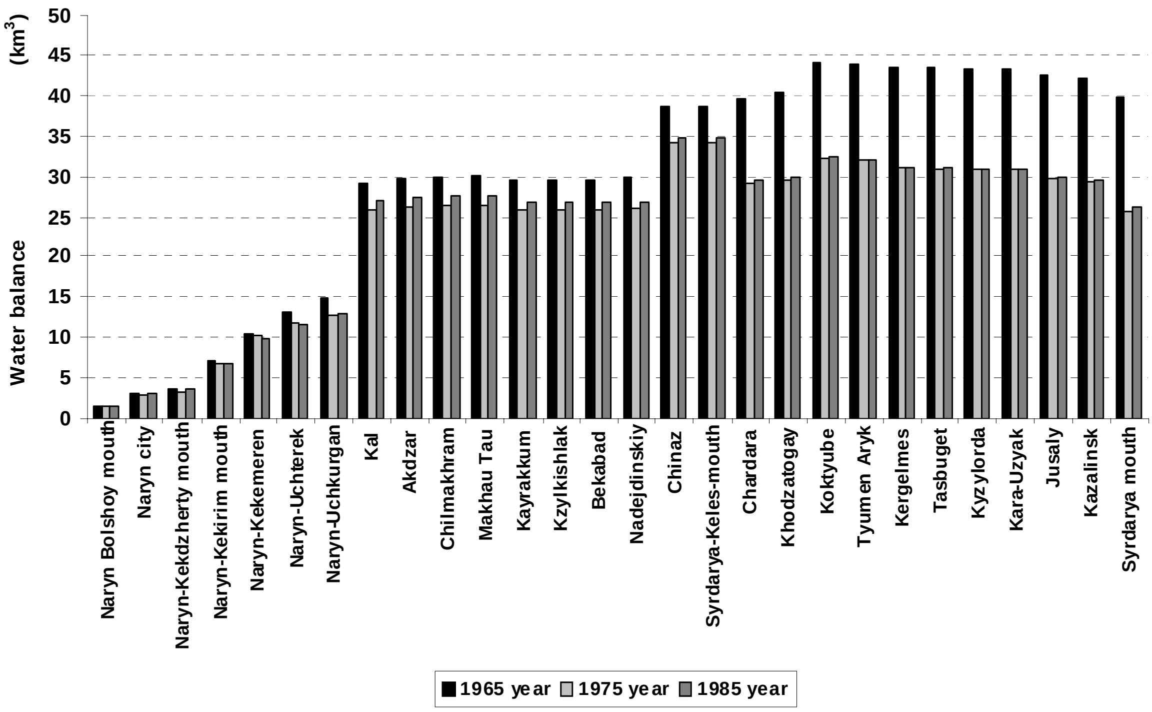

Figure 22. Changes of annual cumulative water balance on hydroposts Syrdarya River on decades.

The causes, which have caused existential changes of water balance, on the nature share on climatic, anthropogenic, on scale of influence on regional, and aboriginal. To the regional factors promoting its decreasing in Syrdarya River basin, raise of air temperature background and decreasing of precipitations amount refer to. Local factors are conditioned to anthropogenic activity.

Headstreams and average flow Syrdarya River for twenty flying less all has been mentioned by changes of economic activities. So, for the seventieth years on a background of a regional drought and filling Toktogulsky reservoir, in place of hydropost Uchterek on Naryn River decreasing of annual water balance on -14.46 % from a level of the sixtieth years is marked. In the eightieth years at small regional raise of precipitations amount and after commissioning Narynsky hydroelectric system decreasing of a water balance has made -12.66 % from a level of the sixtieth years. On the middle flow of Syrdarya River, for Nadejdinsky in the seventieth years decreasing of a water balance has made -13.27 %, in the eightieth years -10.13 % from a level of the sixtieth years.

Significant decreasing of water balance for the period 1970 – 1989 years in the lower flow of Syrdarya River is caused by expansion and an intensification of the agriculture irrigation areas for territory of Kazakhstansky Priaralie – Kazalinsky, Kyzylordinsky, Dzusalinsky, Shieli-Dzanakorgansky and Arys-Turkestansky irrigation fields. For area of hydropost of the mouth Keles River, which is located on an orifice Syrdarya River in Chardarinsky water reservoir, decreasing of magnitude of an annual water balance in the seventieth years has made -11.31 % and in the eightieth years -9.90 % concerning a level of the sixtieth years. For hydropost Chardara located at the inferior transit of Chardarinsky water reservoir on distance 65.4 km from a hydropost a mouth Keles River, in the period 1970 – 1989 years is observed intermittent decreasing of a water balance up to -25.52 % and -26.06 % accordingly in comparison with a level of the sixtieth years. As it was specified above (Figure 4), the greatest local losses of water are observed on Arnasaysky reservoir (Table 2).

Values of the total losses from Arnasaysky reservoir are computed as a difference between the measured data on hydroposts Syrdarya River - Chardara, and Syrdarya River - mouth of Keles River, minus of losses of water resources from Chardarinsky reservoir.

Table 2. The losses of water resources for Arnasaysky reservoir.

Time period	Losses of water resources km^3/year		
	Total, including	for evaporation	other
1970-1979	-5.76	-5.76	0
1980-1989	-6.41	-5.94	-0.47

The analysis of the received results shows, that for the seventieth years the Arnasayskiy water basin was not used in the economic purposes and consequently the general losses of water stocks are equal to losses on evaporation (*Table 2*). For the eightieth years on this area the agricultural irrigated fields were created. It was the reason of additional withdrawal water on irrigation in volume *-0.47 km^3/year*. The share of Arnasayskiy water reservoir in the general losses of water store relatively of value of potential water balance has made on the average for the period:

- 1970-1979 years 14.21 % from total water balance of Syrdarya River basin, which had value 25.64 km^3/year;
- 1980-1989 years 16.16 % from total water balance of Syrdarya River basin, which had value 25.07 km^3/year.

Cumulative losses of a water balance on the new agricultural areas and irrigational nets in areas of an irrigation farming of the Kazakhstan Priaralie estimates in limits -4.15 km^3/year for the seventieth years and -2.44 km^3/year for the eightieth years. Over-all climatic losses of a water store of Syrdarya River basin for twenty years of a drought estimate in limits -4.45 ÷ -4.95 km^3/year.

Average water balance on decades

Spacing distribution of average annual water balance volumes from elementary platforms *(area 30 geogr. sec.* 30 geogr. sec. $\approx$ 1 km^2)* in the season up to the end of the sixtieth years gives representation about potential water resources in Syrdarya River basin (Figure 23). In a zone of diffusion the climatic caused arid landscapes the water balance northern and north-western part of region is equal 0 ÷ 20000 m^3/km^{2}year. On plains of the central part of basin the average annual water balance changing in limits 20000 ÷ 50000 m^3/km^{2}year. All mountain terrains are characterized by positive values of an annual water balance and are the main supplier of water resources in basin p. Syrdarya. In mountain Karatau and Borolday ridges the average annual balance is equal 150000 ÷ 250000 m^3/km^{2}year. The highest values of an annual water balance in Western Tien-Shan are fixed in the interval of 800000 ÷ 1600000 m^3/km^{2}year. The little smaller values of an annual water balance in Talassky, Kyrgyzsky, Fergansky and Alaysky ridges, which are in limits 800000 ÷ 1300000 m^3/km^{2}year. In mountain areas of Internal Tien-Shan of magnitude of an annual water balance are in the interval 400000 ÷ 700000 m3/km2year. Droughty intra mountain depressions of a western part of this range have average annual balance of limits 0 ÷ 50000 m3/km2year. In a Turkestansky ridge an average annual water balance rather low 250000 ÷ 400000 m3/km2year. Intrazonal and anthropogenic changed landscapes are marked as range with negative values of average annual balance. Intrazonal landscapes are introduced to marshy deltas of the Syrdarya and Amudarya Rivers with numerous shallow lakes, the extensive areas of solonchaks to a left bank of the lower flow Syrdarya River and river's inundation meadows. Typical values of an average annual water balance in these zones for the sixtieth years -50000 ÷ -100000 m^3/km^{2}year. Bayrkum-Chardarinsky and Fergansky irrigation areas refer to anthropogenic landscapes on the middle flow of Syrdarya River, Kazalinsky, Kyzylordinsky, Dzusalinsky, Shieli-Dzanakorgansky agricultural irrigation areas in the lower flow of Syrdarya River, which have of volumes deficiency of a water balance -100000 ÷ -200000 m^3/km^{2}year, and places up to -350000 m^3/km^{2}year. The greatest losses of water resources in conversion per unit are dated the area for water reservoirs that is caused by very high intensity of average annual evaporation in this period (Figure 20). Chardarinsky, Kayrakkumsky water reservoirs, other numerous shallow lakes and artificial water reservoirs in the sixtieth years lost water on the average e-1400000 ÷ -1600000 m^3/km^{2}year. But the most potent user of water resources in region is Aral Sea. Ranging on marginal north-western of terrain, it does not differ of maximum high intensity of leakage of water -700000 ÷ -1100000 m^3/km^{2}year, but having the greatest area of evaporation Aral Sea is the main natural user of water resources of basin. In the period up to 1969 years average annual deficiency of a water balance from all area of aquatory has made -51256 m^3/km^{2}year.

The annual water balance for the season 1970 – 1979 years to the full reflects changes of a climatic regime and intensifying of economic activities in Syrdarya River basin (Figure 24). Owing to increase of air temperature (Figure 8) and decreasing of precipitations amount in north-western and eastern parts of basin (Figure 14) the annual water balance also has decreased also a zone of its zero values has extended. In ranges of diffusion of river river-delta and inundated landscapes deficiency of water balance has amplified up to -100000 ÷-150000 m^3/km^{2}year, and for the areas of intensive irrigation agriculture up to -150000 ÷ -250000 m^3/km^{2}year.

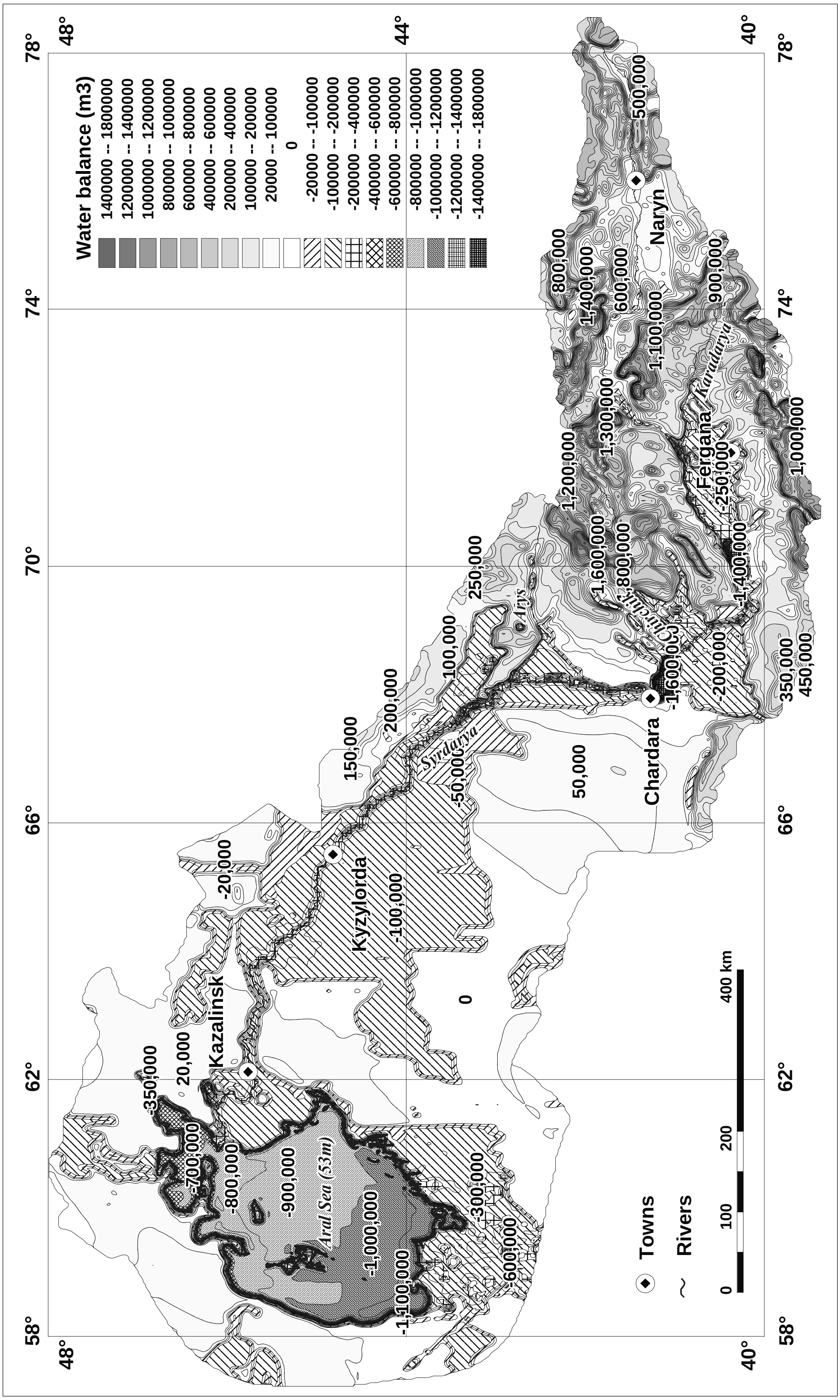

Figure 23. Map of average annual water balance (m^3) of Syrdarya River basin for the sixtieth years.

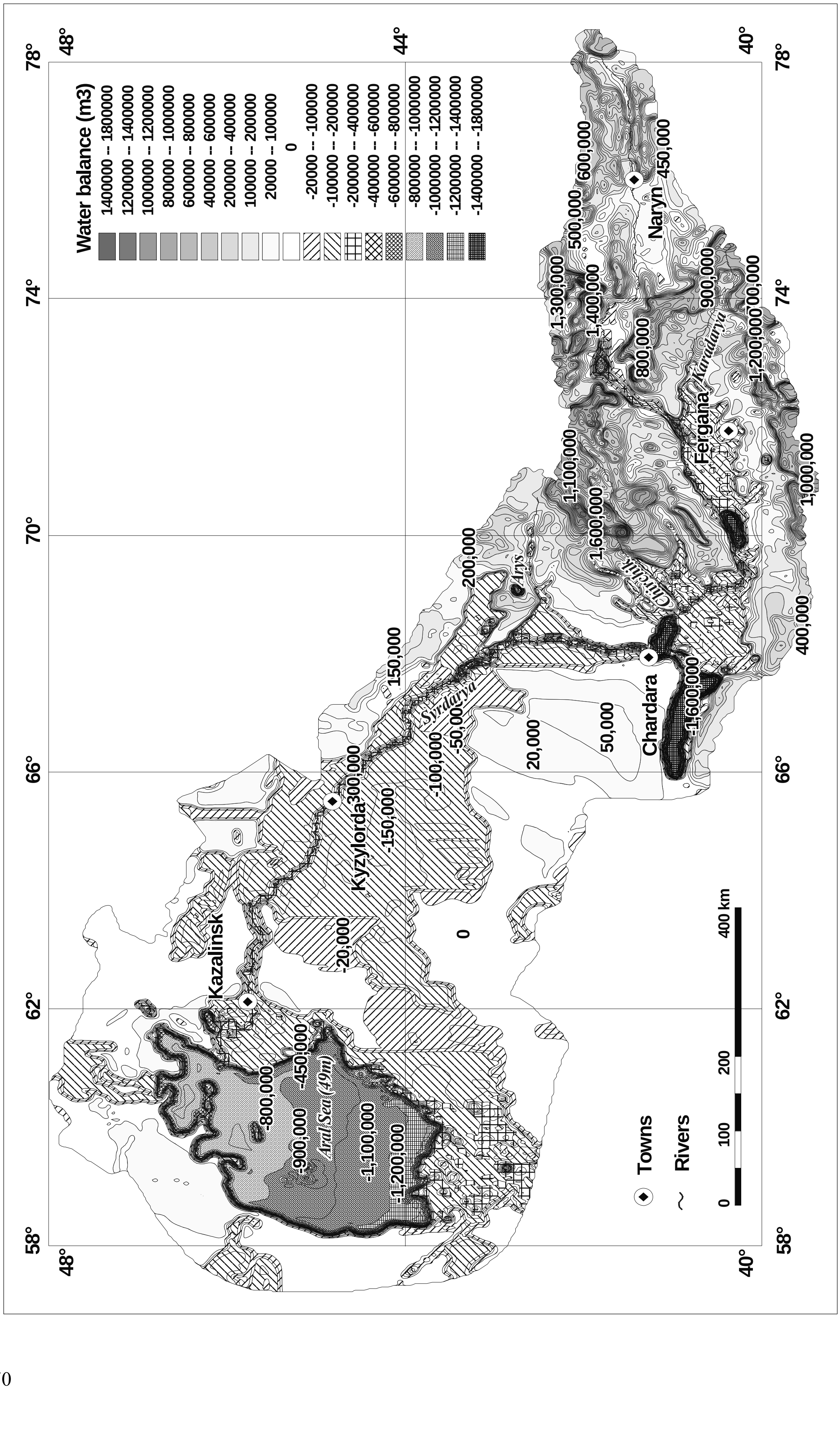

Figure 24. Map of average annual water balance (m^3) of Syrdarya River basin for the seventieth years.

Because of level rise of underground water, as consequences of an intensification of irrigation, the area of solonchaks in a left bank of the lower flow Syrdarya River has extended so, that has merged with the analogous areas of delta Amudarya River. In mountain Karatau and Borolday ridges the average annual balance has decreased up to 100000 ÷ 200000 m^3/km^2year maximum high values of an annual water balance 800000 ÷ 1600000 m^3/km^2year are dated for a middle-high-mountainous zone of Western Tien-Shan. Values of a water balance in Talassky, Kyrgyzsky, Fergansky and Alaysky ridges are limits 800000 ÷ 1400000 m^3/km^2year. In mountain areas of Internal Tien-Shan the annual water balance of the seventieth years varies in the interval 450000 ÷ 600000 m^3/km^2year. Average annual water balance for Turkestansky ridge has remained constant 250000 ÷ 400000 m^3/km^2year. Formed in the seventieth years middle-mountainous Toktogulsky water reservoir has negative average annual balance -1000000 m^3/km^2year. Flat Arnasaysky, Chardarinsky and Kayrakkumsky water reservoirs also has negative average annual balance up to -1600000 m^3/km^2year. Owing to decreasing of Aral Sea level in the period 1970 – 1979 years on the average up to 49 m augmentation of the shallow area with the increased level of evaporation (Figure 24), deficiency of a water balance of its aquatory has increased up to -800000 ÷ -1200000 m^3/km^2year. Average annual deficiency of water balance from whole area of aquatory has made -56715 km^3/year. In a zone of a drained seabed at this time have received development solonchaks with average annual balance is -100000 ÷ -150000 m^3/km^2year.

Spacing distribution of an average annual water balance in Syrdarya River basin in the period from 1980 till 1989 years as a whole is close to parameters of the seventieth years and reflects the local differences. Deficiency of a water balance in southern and south-eastern Priaralie up to -100000 ÷ -200000 m^3/km^2year has a little decreased were more precisely marked out contours of the new areas of agricultural development in the lower flow Syrdarya River though deficiency of an average annual water balance of the eightieth years has remained at the same level, as in the seventieth years -150000 ÷ -250000 m^3/km^2year. For Karatau and Borolday mountains the average annual balance of the eightieth years is equal 100000 ÷ 150000 m^3/km^2year. For twenty years in the ranges framing from the eastern part of Syrdarya River basin, there were appreciable changes of a spacing of an average annual water balance. In Western Tien-Shan the water balance has decreased up to 800000 ÷ 1400000 m^3/km^2year. The range of values of an average annual water balance of the eightieth years in Talassky, Kyrgyzsky, Fergansky and Alaysky ridges is in limits 1000000 ÷ 1600000 m^3/km^2year that shows small augmentation of a water balance in comparison with a level of the sixtieth years. In mountain areas of Internal Tien-Shan in the eightieth year raise of a level of an annual water balance up to 500000 ÷ 800000 m^3/km^2year is observed. Thus, in intramountain hollows of a western part of this range decreasing of average annual balance up to marks-20000 ÷ 20000 m^3/km^2year is registered. In a Turkestansky crops the average annual water balance also has increased up to 300000 ÷ 800000 m^3/km^2year. In the eightieth years of magnitude of negative annual balance for new and old water reservoirs have remained constant: for Toktogulsky-1000000 m^3/km^2year, for Arnasaysky, Chardarinsky and Kayrakkumsky -1600000 m^3/km^2year. In the eightieth years the average level of Aral Sea has gone down on the average to 44 m. The total amount of water has decreased, and the area of well warmed up shoal waters has essentially increased. Therefore deficiency of an average water balance of Aral Sea in the eightieth years has increased in comparison with the sixtieth and the seventieth up to -1100000 ÷ -1400000 m^3/km^2year, or -55.849 km^3/year. In connection with decreasing of the area of Aral Sea the zone of a drained seabed, and solonchaks concomitant it has extended with deficiency of average annual balance in limits-100000 ÷-150000 m^3/km^2year. Together with the solonchaks caused by rise of a groundwater table in river-delta ranges and a left bank in the lower flow Syrdarya River, in the eightieth years they formed an extensive float in north-western range.

Variability of water balance between decades

The analysis of annual water balance changes for Syrdarya River basin 1960 - 1979 confirms conclusions of the previous paragraphs of the present report about increase of aridisation level of a climate in region. Total deficiency of water resources during the given period is determined basically by interdecade general increase of air temperatures (Figure 8), lack of natural humidifying of mountains (Figure 14) and economic activities. On a background of the general decreasing of annual water balance of the seventieth years in an interval of values on -20000 ÷ -50000 m^3/km^2year are less, than in the sixtieth years, areas with specific changes of water balance regime (Figure 26) are contrasted marked. For central part of region in local small mountain areas of the east part of Karatau ridge, a south-west ending of Western Tien-Shan and the western ending of Turkestansky ridge areas of interdecade relative increase of annual water balance level on 10000 ÷ 100000 m^3/km^2year are marked. For seventieth years the central and south-west parts of Internal Tien-Shan the area of increased water balance on 20000 ÷ 100000 m^3/km^2year is marked in comparison with a level of the sixtieth years. The most complex and significant changes of annual water balance are observed on junction of Talassky, Kyrgyzsky ridges and north-west ridges of Internal Tien-Shan. Here areas of strong relative interdecade decreasing of water balance on -150000 ÷ -600000 m^3/km^2year closely adjoin to areas of strong relative interdecade increasing of water balance on 150000 ÷ 600000 m^3/km^2year. Zones of intensive development of irrigated fields for Kazalinsky, Kyzylordinsky and Shieli-Dzanakorgansky agriculture areas for the seventieth years are marked as families of local decreasing of values water balance on -50000÷ -100000 m^3/km^2year of less level of the sixtieth years. For new Arnasaysky reservoir interdecade relative deficiency of water balance on -1600000 m^3/km^2year is observed. Interdecade deficiency of annual water balance for Toktogulsky reservoir is equal -1000000 m^3/km^2year. As a result of a shallow water and increased of heating of Aral Sea deficiency of its annual water balance has increased on the average on -100000 ÷ -300000 m^3/km^2year. On separate sites it achieved values up to -800000 m^3/km^2year. Meanwhile, on the drained bottom of change of annual water balance for the period 1970 – 1979 years show positive changes of an increment of its values on 300000 ÷ 800000 m^3/km^2year.

Changes of regime of spatial distribution of annual water balance for the period 1960 – 1989 show its small increase in a northwest part of Syrdarya River basin and its relative decreasing in east part (Figure 27). On plains and for an overwhelming part of mountain territory of change of water balance is variate within the limits of -50000 ÷ 10000 m^3/km^2year. For the western and north-west intermountain depressions of Internal Tien-Shan in the eightieth years essential decreasing of annual balance on -200000 ÷ -600000 m^3/km^2year is marked in comparison with a level of the sixtieth years. On this background in Western Tien-Shan, Talassky, Kyrgyzsky, Fergansky, Alaysky and Turkestansky ridges, and also for separate local river basins of Internal Tien-Shan rather small areas with positive changes of twenty years' changes of annual water balance on 50000 ÷ 400000 m^3/km^2year above a level of the sixtieth years are marked. The eightieth years are characterized as the period of the maximal intensification of economic activity for whole Aral region. Therefore, changes of annual water balance of Kazalinsky, Kyzylordinsky, Dzusalinsky, Shieli-Dzanakorgansky, Arys-Turkestansky, Bayrkum-Chardarinsky and Fergansky irrigation fields are marked as areas of interdecade relative decreasing of its values on -75000 ÷ -100000 m^3/km^2year. For area of an arrangement of Arnasaysky reservoir interdecade relative deficiency of water balance on -1600000 m^3/km^2year is observed. Interdecade deficiency of average water balance of Toktogulsky reservoir is equal -1000000 m^3/km^2year. As a result of strong falling a level and a shallow water of Aral Sea for twenty years its water balance has essentially gone down on -250000 ÷ -450000 m^3/km^2year. For a zone of its drained bottom evaporation has sharply decreased, and consequently interdecade relative increase of annual water balance on 500000 ÷ 800000 m^3/km^2year here is observed.

According to modelling change of a water balance for the season with 1970 on 1989 years educed as follows:

- For the period 1970 – 1979 years the annual water balance has decreased for -14.23 km^3/year from a base level of the sixtieth years, including:
  - over-all the climatic caused deficiency of a water balance of Syrdarya River basin for ten years of a drought with 1970 on 1979 years estimated in limits -4.45 km^3/year;
  - annual leakage of water for Arnasaysky water reservoir, which formed in the beginning of seventh decade, had volume -5.63 km^3/year;
  - joint losses of a water balance on the new agricultural areas and irrigational nets in areas of irrigation farming of the Kazakhstan Priaralie estimated in limits -4.15 km^3/year.
- For the period 1980 – 1989 years the annual water balance has decreased -13.80 km^3/year from a base level of the sixtieth years, including:
  - over-all the climatic caused deficiency of a water balance of Syrdarya River basin for twenty years of a drought with 1970 on 1989 years estimates in limits -4.95 km^3/year;
  - annual losses of water resources with formed in the beginning of the seventieth years of Arnasaysky water reservoir had volume -6.41 km^3/year;
  - joint losses of water stores on the new agricultural areas and irrigational nets of the Kazakhstan Priaralie estimated -2.44 km^3/year.
- • Shallows of Aral Sea for twenty years has caused intensifying evaporation from its surface, decreasing of precipitations amount and increase of air temperatures has resulted in progressing deterioration of a water balance of its aquatory, including:
  - for the normative period up to 1969 years at the average area of aquatory is 57050 km2. The losses of annual balance are equal -51.26 km^3/year or -898510 m^3/km^2year;
  - for the period 1970 – 1979 years at the average area of aquatory decreased up to 56770 km^2. The losses of annual balance are achieved -56.72 km^3/year or -999119 m^3/km^2year;
  - for the period 1980 – 1989 years at the average area of aquatory decreased up to 46070 km^2. The losses of annual balance are equal -55.85 km^3/year or -1212286 m^3/km^2year.

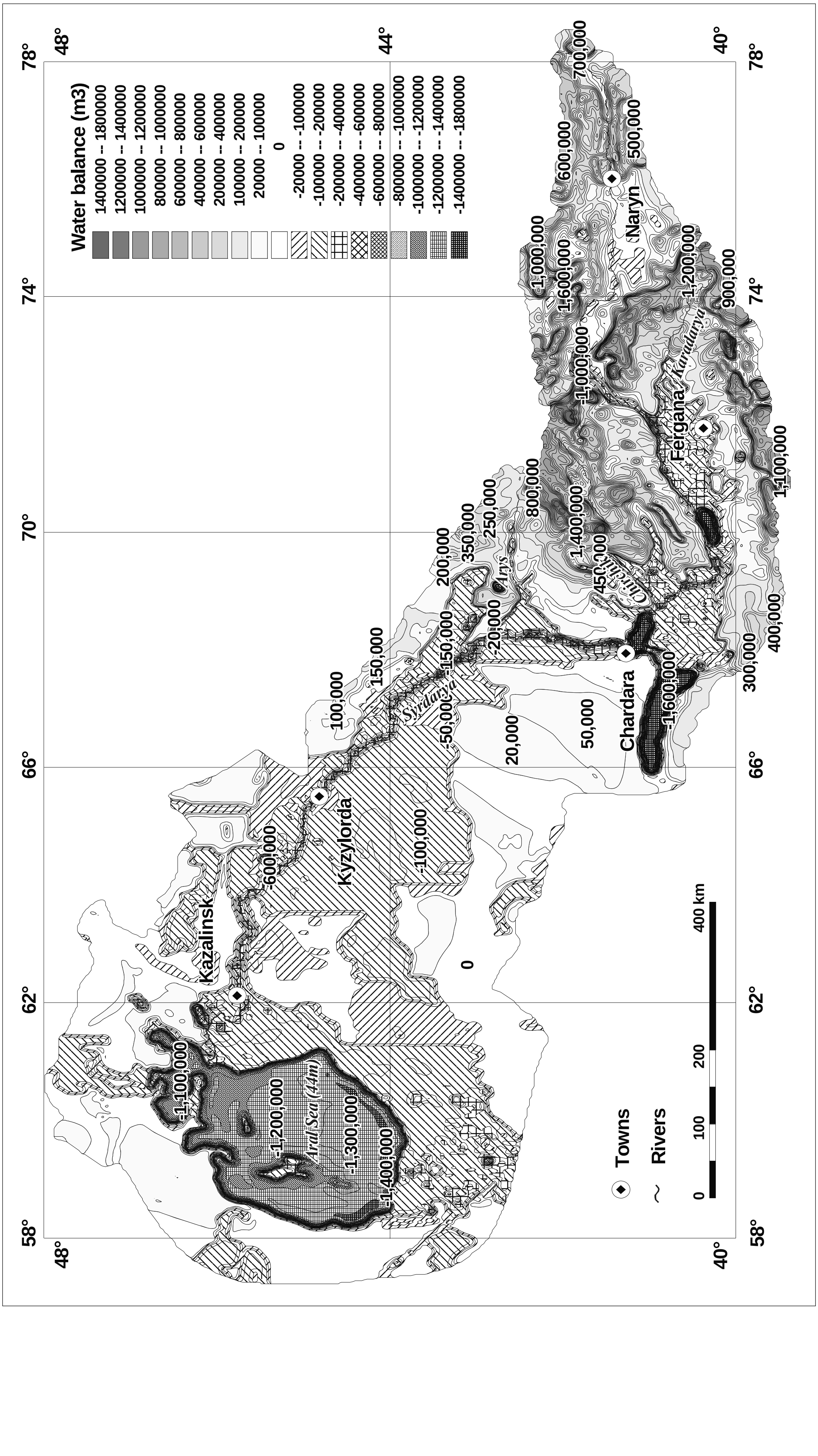

Figure 25 .Map of average annual water balance (m^3) of Syrdarya River basin for the eightieth years.

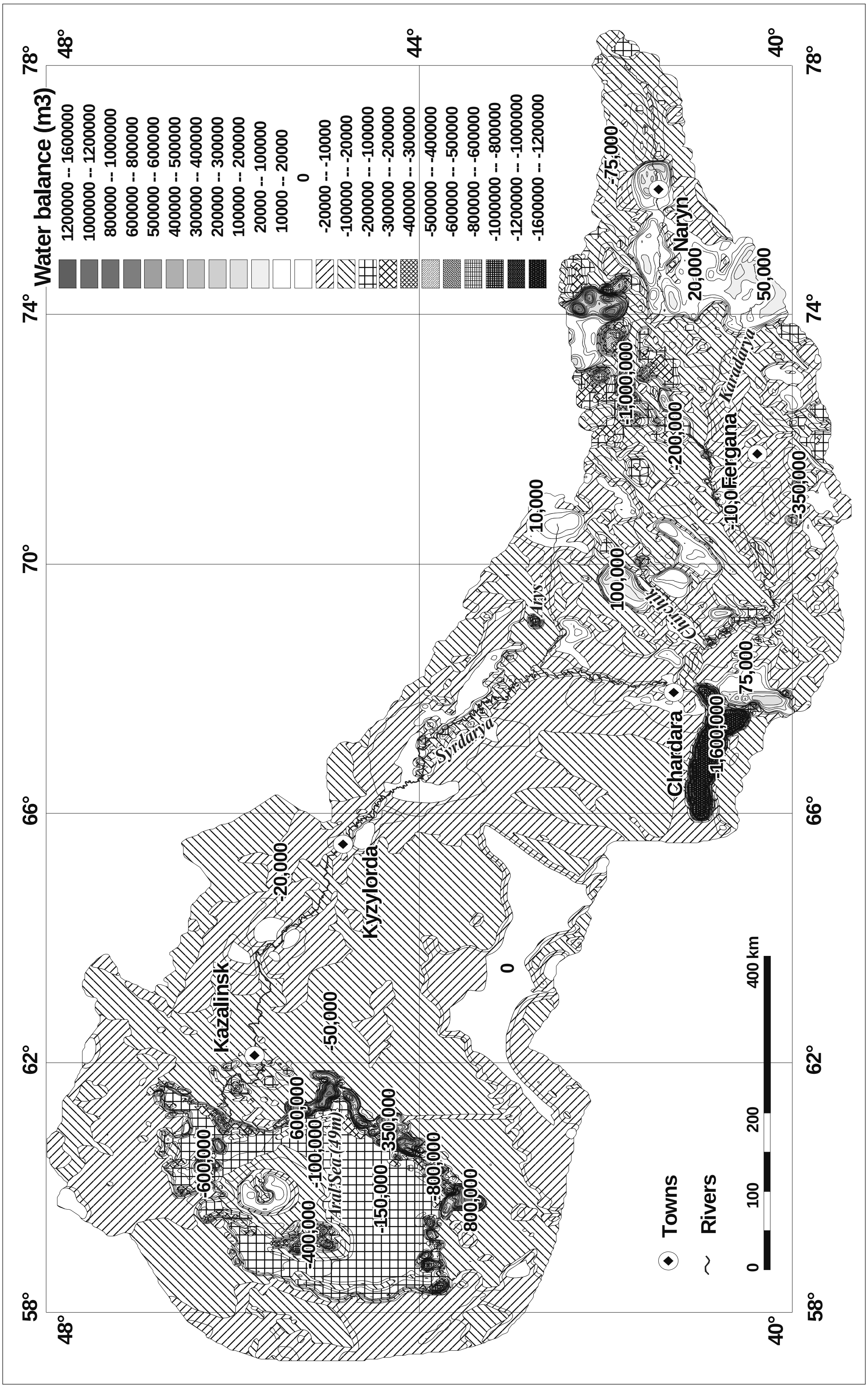

Figure 26. Map of differences between average annual water balances (m^3) of Syrdarya River basin for the seventieth and sixtieth years.

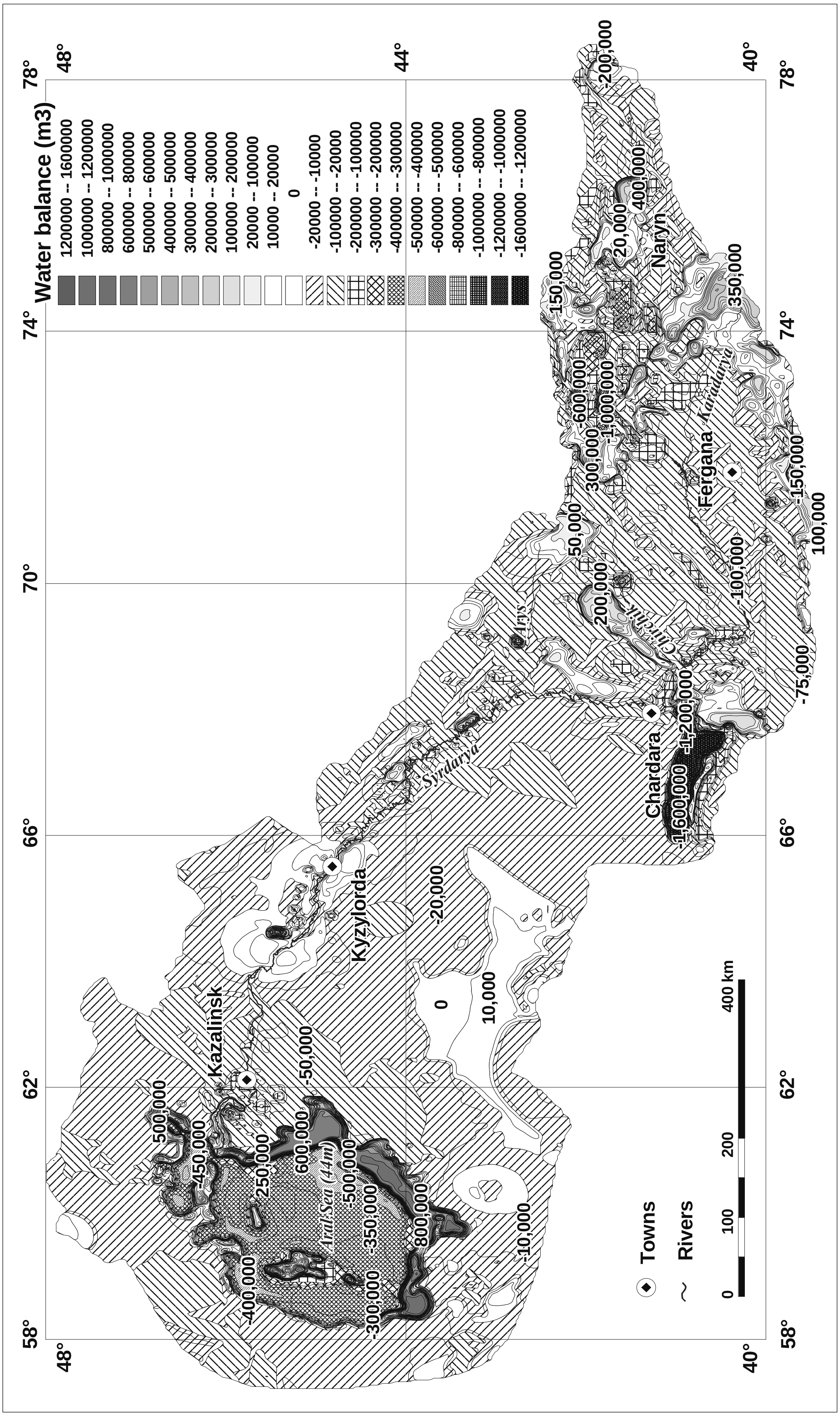

Figure 27. Map of differences between average annual water balances (m^3) of Syrdarya River basin for the eightieth and sixtieth years.

Conclusion

The analysis of existential changes of climatic indexes in Syrdarya River basin testifies that the twentieth years from 1970 until 1989 years is characterized by change such as regional atmospheric circulation, which began in the seventieth years and stabilized in the eightieth years. As a result of it due to increase of winter air temperatures in region, which was a increase of annual temperatures of air on magnitude ***0.3 ÷ 1.2 °C*** from a level of the sixtieth years. Influence of anthropogenic activity on formation and change of a temperature regime was local character and has been dated for large human settlements with the developed infrastructure, to irrigated agricultural areas and man-made reservoirs. On the after-effects anthropogenic loads did not render significant effect on the over-all climatic status of Syrdarya River basin. The greatest influence of economic activities on an aboriginal climate was showed in area of Aral Sea and other water reservoirs. On a measure of decreasing of the area of aquatory of Aral Sea the temperature regime of adjoining to it dry land varied aside the greater aridisation. Around of new created water reservoirs the aboriginal climate was softened due to relative lowering of summer air temperatures. Range of cooling influence of water surfaces on environing land does not exceed 10 ÷ 20 % from the dimensions of their aquatories and is profiled by dominating wind flows.

Over-all regional decrease of precipitations amount for the period 1970 – 1989 years on ***5.52 ÷ 8.15 %*** from a level of the sixtieth years allows to characterize it as moderately droughty. Conversion of regime precipitation storage educed in a direction of total decreasing of precipitations on plain, low mountainous zone and intra mountain depressions of Internal Tien-Shan. At the same time, the particulate increasing of precipitations amount in middle mountainous and high-mountainous zones, which opened for water transfer of mountains of Western Tien-Shan, was registered.

As whole changes of evaporation of Syrdarya River basin reflected processes of conversion of precipitation storage regime in region. Intra annual distribution of evaporation for the normative period 1960 –1969 years shows that on plains and in low mountainous zone for ultraarid climatic zone the maximum evaporation from dry ground is limited by amount of precipitations and consequently it is dated for the most humidified spring and autumn seasons. For middle mountainous zone with semi-humid both humid types of landscapes and spring-and-summer maximum precipitation storage the season of intensive evaporation is shifted aside summer season. For high-mountainous zone the season of the maximum evaporation is limited by thermal regime and consequently restricted only to summer season. Middle-high-mountainous zones are the most intensive evaporators of a dry land up to 600 mm/year. Ranges of the maximum evaporation in region are dated for aquatories of planting water reservoirs of southern part of basin and attain magnitudes 1400 ÷ 1600 mm/year.

The period 1970 – 1989 years is characterized by over-all increase of evaporation in the lower flow Syrdarya River and above aquatory of Aral Sea as a result of regional increase of air temperatures, appearance in the seventieth years in southern part of basin of new shallow water reservoirs and enhancing shallows of Aral Sea, expansion of the areas of irrigation farming under water consumption agricultural crops – cotton and rice, construction of new irrigational nets on old technologies. Water balance of Syrdarya River basin it is formed under effect of two factors – climatic and anthropogenic. The relative analysis of results of modelling of a potential water balance and the measured parameters of a river flow shows to the sixtieth years as a result of economic activities total losses of water stores in Syrdarya River basin for hydropost Kazalinsk was ***-74.91 %.*** It characterizes a situation with water resources to the beginning of the sixtieth years as the extremely stressed and unstable.

Changes of water balance of period from 1970 until 1989 years registers its decreasing from a base level of the sixtieth years up to ***-13.80 ÷ -14.23 km³/year***. It has finally inferred hydrosystem from unstable equilibrium and has resulted in a progressing degradation of Aral Sea. Thus, over-all climatic losses of water resources of Syrdarya River basin for the twenty years' of a drought period annually is estimated ***-4.95 km³/year***. Leakage of water only from aquatory of Arnasaysky water reservoir have made ***-5.63 ÷ -6.41 km³/year***. Taking into account the given circumstance and that fact, that the given reservoir carries out only function of the temporary store of seasonal flooding waters, conservation of this reservoir is represented inexpedient.

Total losses of water stores on the new agricultural areas and irrigational nets of irrigation farming areas of the Kazakhstan Priaralie estimates in limits ***-2.44 ÷ -4.15 km³/year***. Shallows of Aral Sea has caused augmentation of tempo of evaporation from its surface that together with decreasing of precipitations amount and increase of air temperatures has resulted in progressing deterioration of a water balance of its aquatory.

The analysis of a developed regime of water requirement in Syrdarya River basin evidences of the situation in region completely not hopeless and is not conditioned to an overpopulation or very big development agricultural sector. Huge volumes of withdrawn water resources are spent not so much on economic requiring, how many lost in sand in unlined main irrigation channels and also irrationally evaporates in extensive shallow man-made reservoirs of southern part of basin.

Measures on optimization of water use for Syrdarya River basin, which about eight cubic kilometres of water annually are capable to save and to secure local population against threat of flooding, are reduced to the following:

1. Systematic modernization of the main channels by a method of facing by waterproof materials and optimization of an irrigational network by means of the termination of access of water in not used irrigation canals can raise factor of their use from 0.50 till ÷ 0.70.
2. Reorientation of structure for local agricultural due to reduction of the areas borrowed by the most water-capacious cultures – rice and a clap about advantage of less water-capacious cultures and animal industries, and/or translation of rice and cotton fields to less water-permeable of soils will allow to lower water consumption agricultural sector on 10 ÷ 30 % at preservation or increase of its profitability.
3. Deepening and flattening of channel Syrdarya River bed for the its lower flow, and also carry of the settlements which are being a zone of seasonal flooding, to more safe places or construction of protective dams and drainage systems around of them will reduce social and economic consequences of seasonal high waters.
4. Gradual liquidation of Arnasaysky reservoir will enable for productive use of those water resources which now irrationally evaporate from a surface of the given reservoir.
5. The interstate coordination of an intraannual mode of water use for prevention of uncontrollable freshet dumps of water, and also development of scientifically proved national quotas and modes of use of water resources will help to remove intensity in the interstate attitudes connected and use of water resources of the Aral region. Maintenance of the independent and transparent tool control over execution of the accepted normative documents will allow to minimize probability of not authorized use of water resources.

These problems are economically expedient and quite solved at presence of political will of the states of the countries of the Aral region and financing of corresponding engineering projects.

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Резюме

Гречаниченко Ю. **Климатическая характеристика бассейна р. Сырдарья**

В статье рассматриваются результаты пространственно-временного моделирования климатических показателей температуры воздуха, осадков, испарения и потенциального водного баланса бассейна р. Сырдарьи за период с 1960 по 1989 годов, времени наиболее интенсивного хозяйственного освоения Аральского региона. Представленный картографический материал наглядно иллюстрирует динамику этих процессов.

Анализ результатов моделирования позволяет оценить период семидесятых – восьмидесятых годов как умеренно засушливый с общим повышением средних годовых температур на 0.3 ÷ 1.2 °C и уменьшением сумм средних годовых осадков на 5.52 ÷ 8.15 % от уровня до шестидесятых годов двадцатого века.

Сравнительный анализ рассчитанных показателей водного баланса и результатов оценки гидрологического режима показывает, что уже в начале шестидесятых годов суммарные потери водных запасов в бассейне р. Сырдарьи составляли до 74.91%. Это характеризует ситуацию с водными ресурсами тех лет как крайне напряжённую и неустойчивую.

Строительство и ввод в эксплуатацию новых гидротехнических сооружений в конце шестидесятых семидесятые годы привело к существенному пространственному перераспределению водных ресурсов в бассейне за счёт их накопления в наиболее интенсивно испаряющей южной части территории. По модельным оценкам ежегодные потери воды только с акватории Арнасайского водохранилища составляют в среднем 5.63 ÷ 6.41 $км^3$/год, а совокупные потери водных запасов на новых сельскохозяйственных площадях и ирригационных сетях на массивах орошаемого земледелия Казахстанского Приаралья оцениваются в пределах 2.44 ÷ 4.15 $км^3$/год.

Оптимизация и планомерная модернизация ирригационной сети и доведения коэффициента их использования до 0.7, ликвидация многочисленных южных водохранилищ и углубление русла р. Сырдарьи в нижнем течении способно сэкономить до восьми кубических километров воды ежегодно.