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Scientific Information Center of the Interstate Coordination Water Commission of Aral Sea Basin
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National Ecological Society of Kazakhstan

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ECONOMICAL ASSESSMENT OF JOINT AND LOCAL MEASURES FOR THE REDUCTION OF SOCIO-ECONOMICAL DAMAGE IN THE COASTAL ZONE OF ARAL SEA

Project INTAS–ARAL 2000 -1059

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CONTENTS:

INTRODUCTION

Project INTAS -1059 «Kazakh Prearalie» has accumulated enough analytical, field and hydrological (GIS, RS) data to transit from damage assessment to evaluating measures necessary to stabilize social-economic and ecological situation and simultaneously to restore previous Syrdarya delta productivity both in natural and social aspect.

This work is the final report on the project and it consists of following components:

- Summary of last year report determining main content, directions and volumes of damage caused by the Aral Sea shrinking and delta degradation where this damage is bounded with the area;
- Comparative analysis for North and South Prearalie;
- Description of ongoing projects in Kazakh Prearalie and their expected impact on situation, analysis of accepted provisions;
- Results of field expeditions and local population interrogatories to reveal necessary additional measures;
- Action plan and proposals.

PREAMBLE

Tragedy of the Aral Sea basin has been known among scientific society and the public for decades. Ecological tension in the Aral Sea region is heightened mainly due to economic reasons. Expansion of irrigated areas in Kyzylorda oblast and, particularly, development of lands in upper and middle reaches of the Syrdarya river along with the establishment of new and more productive natural-economic systems have led to disturbance of natural balance between aquatic and sub-aquatic geosystems, occurrence and development of unfavorable natural processes that finally represent a danger to man himself. Trends, rates and scale of desertification processes are characterized by several factors, but human activity has become the determinant for environmental degradation.

Lack of radical political and legal measures at the interstate level casts doubt on existence of uniform natural system of the Aral Sea basin.

Organizational and legal approaches for overcoming ecological crisis in Kazakhstan's part of Prearalie conditionally can be divided into three periods.

1. Late Soviet period (1986-1991) is characterized by the fact that initiatives for solving the Aral Sea problems came from the government of USSR, which developed the strategy of actions on the basis of All-Union and regional interests and with account for environmental and socio-economic conditions of local population.

2. Initial period, when the Republic of Kazakhstan carried out measures to eliminate consequences of the sea shrinkage (1992-1993), was remarkable for unjustified euphoria. Some decisions were made with no account for actual situation and a need for provision with required resources.

Decree of the Supreme Soviet of Kazakhstan of 18 January 1992 “About urgent measures for the radical change of living conditions in Prearalie» declared the ecological disaster zone, which included all rayons of Kzyl-Orda oblast and city Kzyl-Orda and several rayons of Aktyubinsk, Chimkent and Dzhezkazgan oblasts”.

In this context the Cabinet of Minister of Kazakhstan issued decree No. 280 on 25 March 1992 «About urgent actions for improving the socio-economic and environmental conditions in Prearalie». It proposed to ministries, departments, and oblast administrations to provide funding for construction and rehabilitation of social and industrial works in Prearalie. The Cabinet of Ministers ordered to develop state program for saving the Aral Sea and recovering ecological balance in Prearalie by 2006 (“Aral-2006”). All previous decrees - issued by the Council of Ministers of Kazakh SSR and the Cabinet of Ministers of Kazakhstan relevant to implementation of former soviet government's decrees - were repealed.

3. Current period of implementing - in the Republic of Kazakhstan - measures to eliminate consequences of environmental disaster in Prearalie is connected with great economic difficulties. They forced to abandon the state program «Aral-2006» and measures set by the decree of the Cabinet of Ministers “About urgent actions for improving the socio-economic and environmental conditions in Prearalie”.

The law of Kazakhstan of 30 June 1992 on «Social security of citizens suffered from ecological disaster in Prearalie» was enacted with massive efforts. The effect of this law was partially suspended. Thus, the last law in this regard was adopted on 16 November 1999 «On suspending several articles of the Law of Kazakhstan on social security of citizens suffered from ecological disaster in Prearalie».

Just recently the situation has changed to the better.

For the first time the republic's budget for 2001 included costs of projects for regulating Syrdarya and conserving the northern part of the Aral Sea, for providing settlements in the Aral Sea region with water supply and sanitation, as well as costs of searching for tap water leakage and installing water meters within the project “Water supply for Kazalinsk (Novokazalinsk)”.

Two important agreements were ratified:

- by Kazakhstan's law No. 161 of 1 March 2001 - Loan agreement (water supply project for city Aralsk (the Aral Sea region)) signed on 11 May 2000 between the Republic of Kazakhstan and Kuwait Fund for Arabian Economic Revival;

- by Kazakhstan's law No. 307 of 20 March 2002 – Loan agreement (Regulation of Syrdarya and conservation of the northern part of the Aral Sea (phase 1)) signed on 22 October 2001 between the Republic of Kazakhstan and The World Bank of Reconstruction and Development.

Implementation of given project INTAS-Aral 2000-1050 is an important step taken by European Union for evaluating socio-economic and environmental damage caused by drop of the Aral Sea level, which will allow us to justify a need for further governmental actions towards the protection of Prearalie and to prepare ecological base for drastic actions to be taken for creating new environmentally sustainable system within the boundaries of South and North Prearalie.

I. DEGRADATION OF NATURAL SYSTEM IN PREARALIE CAUSED BY THE SHRINKAGE OF THE ARAL SEA

Among present global ecological problems, such as climate warming and the loss of resource capacity in natural systems, desertification processes in the Aral Sea basin take one of particular places.

The Aral Sea problem appeared in late sixties and resulted from inappropriate agricultural production and water consumption. Aquatic and sub-aquatic landscapes in near-shore zone have undergone the most transformation.

The problem of natural degradation both in Northern and Eastern Prearalie due to shrinkage of the Aral Sea was addressed by a number of researchers, such as I.P. Gerasimov et al. [1], V.M. Borovskiy [2], N.F. Mozhaytseva [3], V.A. Korniyenko et al. [4/, G.V. Geldiyeva et al. [5], L.Ya.Kurochkina et al. [6], O.Ye. Semyenov [7], U.M.Ahmedsafin et al. [8], Yu.P. Khrustayev et al. [9], A.A. Rafikov [10, 11], N.M. Novikova [12], and L.I. Kurochkina [13].

Review of such works on Prearalie as a whole and on Southern Prearalie was done at SIC ICWC under the project INTAS-1733 and published in brochure “Evaluation of socio-economic consequences of ecological disaster - shrinkage of the Aral Sea”, Tashkent, SIC ICWC, 2001.

1.1. Factors causing degradation of natural systems

Major factors that have caused degradation of natural systems in the region are as follows: disturbance of water-salt balance in the Aral Sea; changes in the state of lakes in delta; activation of deflation-accumulation and impulverization processes; drop of groundwater table and increase of their salinity; degradation and salinization of hydromorphic soils within the rivers Amudarya and Syrdarya; over-pasturing and excessive mowing; and, irrigation and man-caused influence.

1.1.1. Decrease of inflow to Syrdarya river delta and to the Aral Sea

Up to middle of the past century level and hydrochemical regime of the Aral Sea had been determined by inflow from the rivers Amudarya and Syrdarya. Last decades we have been observing continuous degradation of aquatic inland system due to putting into operation of several large reservoirs and regulation of surface flow.

As N.M.Novikova [12] and I.M.Mal'kovskiy [14] notes, since 1960 cumulative river flow, even in flow formation area, has decreased considerably: from 117 km^3/year in 1961-1970 to 100 km^3/year in 1971-1975.

In 1911-1960 general flow of the rivers Amudarya and Syrdarya in flow formation area was 117 km^3/year, of which 80km^3/year - Amudarya and 37 km^3/year - Syrdarya. At the same time actual inflow to the Aral Sea did not exceed 56 km^3/year, including 42 km^3/year from Amudarya and 14 km^3/year from Syrdarya.

Retrospective analysis shows that a share of natural river flow in the sea's water balance for long-term varied quite widely, particularly in the latter half of the past century (Table 1.1.1).

Table 1.1.1
Average minimum and maximum of the Aral Sea level and the cumulative river inflow

Years	Sea level, absolute m**		River inflow, km^3	
	Min	Max	Min	Max
1941-1945	52,67 (I)*	52,97 (VII)		
1946-1950	52,68 (XII)	53,03 (VII)		
1951-1955	52,82 (I)	53,13 (VII)	58,6	76,2
1956-1960	53,13 (I)	53,46 (VII)	40,4	64,4
1961-1965	52,54 (XII)	52,98 (VII)	28,5	48,6
1966-1970	51,29 (XII)	51,69 (VI)	35,2	81,2
1971-1975	49,81 (XII)	50,38 (VI)	8,2	49,5
1976-1979	47,03 (XII)	47,68 (VI)	7,4	19,3
1980-1984	42,75	45,75	1,8	10,05
1985-1989	39,08	41,10	0,6	21,8
1990-1994	36,9	38,24	11,41	32,24
1995-2000	33,98	36,5	5,17	28,53

* Months mentioned in brackets

** Level for the Northern Sea

Before the regulation of river flow and continuous drop of the sea level, flood waters had covered 877.5 km^2 of lands, while area of lake systems in the delta had amounted to 517.73 km^2 /10[a]/. From 1961 to 1970 flow of the Syrdarya river in the delta decreased to 6.7 km^3/year on average, reaching minimum 3.2 km^3/year in 1965 and maximum 10.6 km^3/year in 1969. Annual flow averaged 2.3 km^3/year in 1971-1980 and 0.72 km^3/year in 1981-1986. Total water surface of delta lakes had reduced 1.9 times by mid-seventies and was less than 280km^2, half of which pertained to Kamyshlybash lake system. In early nineties water surface of lakes within Syrdarya delta was 450km^2, with water mass of about 1,5 км^3 in these lakes, while floodwaters covered only 111 km^2 of lands.

Observations of Kazakh Geographical Institute [3] show that since 1987 a tendency has become clear to the improvement of water supply in Syrdarya delta, with average supply at 5,93 km^3/year (Table 2) (7,41 km^3/year according to SIC's data). As a result, water surface of lake systems retained at 450 km^2.

Since 1988, due to renew of releases to the Aral Sea under limited capacities of constructed hydrostructures the delta's water regime has become quite unstable. This had an effect on water supply conditions in delta lakes. Before regulation of the Syrdarya river lake share was 7%. There existed more than 500 lakes, which total area of 1600 km^2, 28 of which had water surface area of more than 10 km^2 (area of lake Kamyshlybash reached 178 km^2). During this period river flow share in water balance of the lake systems averaged 1.87 km^3 /year. Because of abrupt reduction of river flow and stoppage of overflows, number of lakes and their areas have greatly decreased.

During high-water years (1993 – 1994) favorable conditions of natural water exchange between lake systems and river flow were created in the middle delta. As a result about 15% of lakes' water mass was replaced annually by fresh river water that influenced positively on water-salt balances of water bodies.

Next years (1995–1996), due to reduction of general river flow water supply to lake systems in the lower and middle reaches of Syrdarya became very problematic. Poor state of canals which maintain water-salt and level regimes of the lake systems had negative effect in this respect [12].

At present, water to Kamyslybas lake is supplied via four canals: Keragar (length 50 m, width 10 m, depth 2 m); Zhasulan (1,5 km, 10 m 2,5 m); Kuly (0,6 km, 15 m, 5 m); Taldyaral (60 m, 15 m, 2 m).

Akshatou lake system is fed via the following canals: Suykkol' (0,3 km, 6 m, 3 m); Tabeken (0,7 km, 12 m, 3 m); Akkoy (1,5 km, 15 m, 5 m); and, Akshakyz (40 m, 8 m, 2 m)

From 1988 to 1997 many sluices at canals were broken by spring ice drift and backwater from lake systems. Because of lack of funds, repair and maintenance have not been provided. Canal capacities have declined due to obliteration, siltation and bank erosion. Temporal embankments are eroded often and water flows back to the Syrdarya river leading to disturbance of water-salt regime in lake systems.

The government of the Republic of Kazakhstan and local autonomous bodies take radical measures to reduce ecological crisis in Kazakhstan's part of Prearalie. In particular, in 1975–1976 construction of Amanotkel and Aklak waterworks has saved fishing in Kamyslybas, Akshatous and Primorskaya lake systems.

When before 1960 flow of both deltas had averaged 56 km^3/year, area covered by floods was more than 2800 km^2 along Amudarya and 877.5 km^2 along Syrdarya and lake area was 820 km^2 and 517,73 km^2 respectively.

Table 1.1.2
Distribution of river flow in the Aral Sea basin during 1989-1998

		Annual runoff of flow formation zone *			Water consumption by irrigated agriculture zone **			Water consumption by ecological disaster zone (deltas and the sea) **			Changes in Aral's volume (runoff balance)***
		Total	of which		Total	of which		Total	of which		
			Amu darya	Syr darya		Amu darya	Syr darya		Amu darya	Syr darya	
1989	km^3	76,2	47,2	29,0	70,85	46,2	24,65	5,35	1,0	4,35	-30
	%	66	59	79	93	98	85	7	2	15	-8
1990	km^3	98,6	64,2	34,4	86,01	55,2	30,81	12,59	9,0	3,59	-31
	%	85	81	94	87	86	90	13	14	10	-10
1991	km^3	96,9	65,1	31,8	80,71	52,6	28,11	16,19	12,5	3,69	-24
	%	84	82	87	83	81	88	17	19	12	-8
1992	km^3	117,8	81,7	36,1	84,43	52,8	31,63	33,37	28,9	4,47	-13
	%	102	103	99	72	65	88	28	35	12	-5
1993	km^3	11,4	70,5	40,9	83,1	51,7	31,40	28,30	18,8	9,50	-8
	%	96	89	112	75	73	77	25	27	23	-3
1994	km^3	119,3	76,4	42,9	88,33	54,7	33,63	30,97	21,7	9,27	-12
	%	103	96	117	74	72	78	26	28	22	-5
1995	km^3	87,7	58,2	29,5	76,73	53,1	23,63	10,97	5,1	5,87	-16
	%	76	73	81	87	91	80	13	9	20	-6
1996	km^3	103,4	67,3	36,1	91,19	59,8	31,39	12,21	7,5	4,71	-20
	%	89	85	99	88	89	87	12	11	13	-9
1997	km^3	85,7	54,4	31,3	78,27	52,2	26,07	7,43	2,2	5,23	-20
	%	74	69	86	91	96	83	9	4	17	-10
1998	km^3	125,1	82,3	42,8	92,67	58,5	34,17	32,43	23,8	8,63	+6
	%	108	104	117	74	71	80	26	29	20	+3
Av.	km^3	102,2	66,7	35,5	83,23	53,68	29,55	18,97	13,05	5,92	-16,8
	%	88	84	97	81	80	83	19	20	17	-5,8

* - percentage of long-term rate of annual runoff
** - percentage of annual runoff for current year
*** - percentage of the Northern Sea volume at the end of current year

Satellite data allowed us to evaluate actual change in lake area for different – from the point of water availability – years of the last decade:

Amudarya:

- in average water availability year 1984 lake area was 70,2 km^2;
- in high-water year 1997 lake area increased to 120 km^2;
- in low-water year 2000 lake area reduced to 26,0 km^2.

Syrdarya:

- in 1960 lake area was 517,73 km^2;
- in 1982 it was 450 km^2;
- in 2000 lake area reached 262,5 km^2

- in 2002 it increased to 353,4 km^2.

Analysis of the above-mentioned data on the reduction of flooded areas both in Northern and Southern Prearalie shows that such instability does not make it possible to create stable water regulation in Amudarya and Syrdarya deltas. In this context, an active work is carried out to improve situation in Southern Prearalie (GEF, IFAS, NATO and other projects); however, no projects have been undertaken yet for the northern part of Prearalie. Therefore, adequate measures are needed urgently for regulation of water resources that flow to the Syrdarya river delta.

1.1.2. Drop of groundwater level

Drop of groundwater level is one of the main determinants of the environmental state of Prearalie. The main causes of this drop are:

- reduced inflow of surface waters to Amudarya and Syrdarya deltas and their decreased infiltration;
- declined floods, reduction of flooded lands and decrease of lake surfaces that contribute to groundwater as well;
- continuous drop of the sea level, which is the natural basis of drainability, hence there is decrease of groundwater level in a zone of inflow depression curve;
- water-related activities in the Aral Sea basin, in particular pattern of artesian water utilization and their self-spring.

Researchers point out clear relationship between distance from the sea and groundwater level. Taking into account low slopes of the dried seabed (0,0001-0,0005), depression curve is formed in the following way (Fig.1.1.2.1)

Syrdarya:

- depending on distance from the shoreline, groundwater level picture is as follows: 0,1…0,6 km - 0,5…0,7 m, 1,0 km - 0,9…1,5 m, 10 km - 1,2…2,8 m, 100 km - 1,7…5,9 m;(8)

Amudarya:

- similarly as mentioned for Syrdarya, groundwater is bedded on the following levels: 0,5…0,6 km - 0,5 m, 2…3 km - 0,5…2 m, 4…6 km - 2,5…4 m. (Project INTAS-1733)

The change in general erosion basis, as a result of the sea level drop, has led to activation of deep erosion and to retrogression of the Syrdarya river at a distance of 145 km. Operation of Amanotkel waterworks slightly restrains deep erosion. However, during emergency situation in 1996 maximum retrogression was 0,95 m/year. In case when operation of Amanotkel waterworks stops, the process is activated with a rate of 2,3 m/year [14].

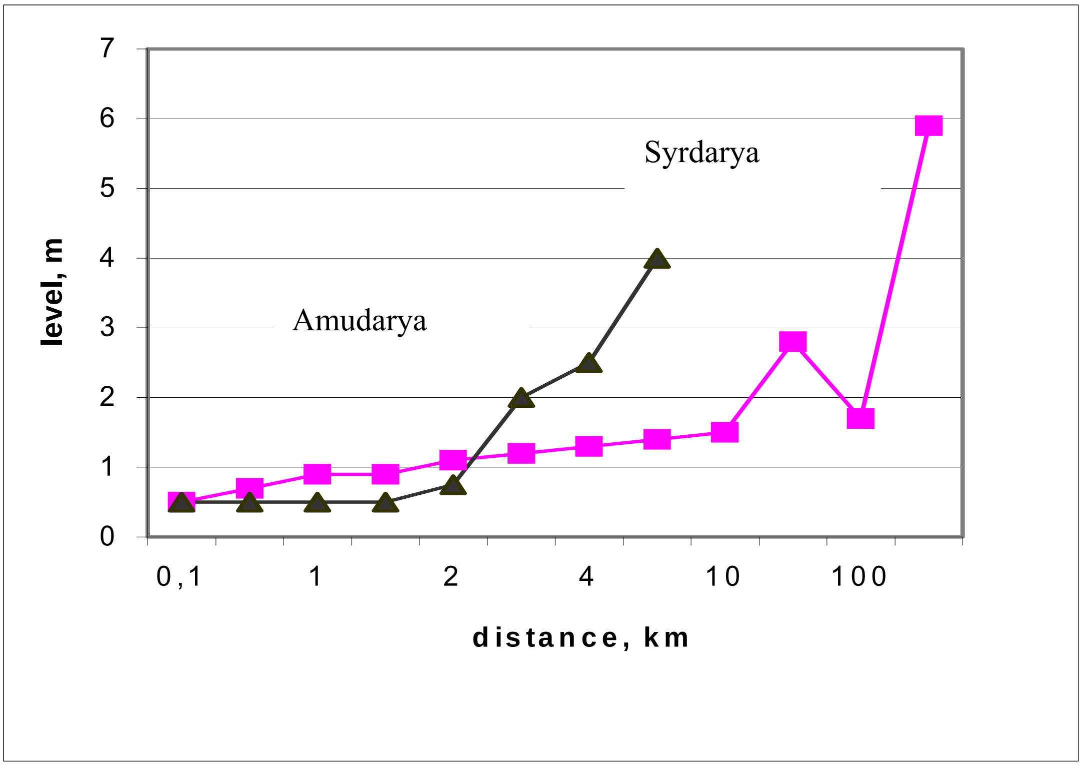


Fig. 1.1.2.1 Relationship between groundwater level and distance from the shoreline

Deep erosion has led to dying-out of before active flow channels and to decrease of groundwater level, particularly within lower floodplain of Aral region. Parallel to retrogression of the river, all-round decrease of groundwater level takes place in the river delta itself both because of the drop of sea level and the reduction of irrigation and particularly river water losses through filtration.

Particularly intensive lowering of ground and artesian waters takes place along the perimeter of the Aral Sea [8].

Within the territory of Kulandy Peninsula forecasted drop of artesian waters is slightly higher and varies from 6-8 m to 9-11 m. As a result of the drop of artesian waters throughout the Aral Sea basin their contribution to groundwater becomes less. This leads to lowering of the latter, particularly in southwester part of Kazakhstan's Prearalie. However, this process slows down as distance from the shoreline increases. In the north and west of the Northern Sea relative stabilization of its level should promote narrowing of the scale of groundwater drop. Total amount of groundwater inflow to water area of the sea is about 130 million m^3/year, with simultaneous inflow of salts from 6,0 to 6,2 million t/year.

Unlike artesian waters, ground waters are very diverse in terms of spatial distribution of salinity and chemistry. They are characterized by horizontal zonality. Exception is ground waters bedded in the upper shallow aquifer, where under the influence of atmospheric evaporatice concentration, irrespective of salinity of lower horizons, highly saline waters are formed. In thick layers of artesian waters, where influence of surface factors is weak, both horizontal and vertical zonality is kept in hydrochemical terms [8].

Within dried bed of the Aral Sea, particularly in its eastern and southern parts, ground waters bedded in higher by hypsometric level terraces and portion of artesian waters in deep horizons are discharged. Almost all groundwater before flowed to the sea now is lost through evaporation. Level of groundwater within the dried bed is falling as the sea dries out.

Within an area of new aral terrace an aquifer spreads from 0,5 to 5 km and is bedded in thin (10-15m) sea- fine-grained sands. Groundwater depth ranges from 3-5 m to 10-12 m. Salinity of water, chemistry of which is mainly chloride-sodium, with high concentration of sulphates and magnesium, tends to increase in terms of time. The least saline are thin floating coarse lenses along coastal dune.

As a whole, drop in groundwater level within an area of Northern Prearalie is shown in Table 1.1.2.1.

Table 1.1.2.1
Relationship between fall of groundwater level (h) on the dried bed and the sea level drop (H) by the end of 1990 [39]

Sea level drop (H), m	**Fall of groundwater level (h) on the dried bed, cm**		
	h_{min}	$h_{average}$	h_{max}
0	181,4	222,0	239,0
1	167,9	197,9	221,7
2	153,8	180,3	209,7
3	141,3	166,8	198,6
4	129,3	155,1	194,1
5	118,2	145,1	189,0
6	107,5	138,1	183,9
7	97,1	130,6	179,9
8	87,4	122,9	177,2
9	77,8	115,6	173,8
10	63,4	108,3	170,3
11	48,0	100,9	166,8
12	36,7	97,1	163,4
13	25,6	93,1	159,9
14	12,5	90,3	150,5
15	0,0	79,0	153,0

The width of groundwater formation zone on the dried bed depends on rates of the sea level drop or on width of dewatering [39].

The total of soluble salts brought by artesian and ground waters to aeration zone of the dried bed was 6,1 million t/year in 1990 and 9,4-10,6 million t/year in 2000. Toxic salts become prevalent in seawater as the sea dries out.

1.1.3. Soil changes in Prearalie

Studies of soil surface in Syrdarya delta in mid XX [15, 16, 17]. The most important theoretical and practical results concerning classification of soils in the river delta and valley and the improvement of soil fertility and irrigated agriculture practices were obtained in 1946-1955 [18, 19].

The new stage of works in the lower reaches of the Syrdarya river was connected with appearing Aral Sea problem. The changes in soil surface were reflected in published papers of Kazakh researchers [20, 21, 22, 23, 24]. Large-scale soil studies in Kazakhstan's Prearalie were conducted in 1949-1958, 1966-1970, 1980-1995.

Every stage of the studies resulted in generation of various scaled soil maps.

Within the framework of given project, based on above mentioned studies, an analysis and assessment of current land fund was carried out and main factors, rates and scale of soil degradation in Syrdarya delta were determined.

The soils in Prearalie are comprised of:
1. Hydromorphic soils of alluvial (delta) valley within meadow and swampy family.
2. Semi-hydromorphic soils – takyrs, takyr-like soils and solonchaks.
3. Sandy soils that are mainly the product of reprocessed alluvial, dealluvial-proalluvial and lacustrine sediments.
4. Automorphic zonal soils – brown and grey-brown soils.
5. Soils of the dried bed.

The whole irrigated land fund of the region is concentrated in the Syrdarya delta. Changes in ecological situation in Prearalie, related to regulation of Amudarya and Syrdarya river flows and to shrinkage of the Aral Sea, induce desertification processes, leading to the loss of natural capacities of delta's soils and the reduction of their biological productivity and fertility.

Soil surface in the delta is formed under influence of:

- hydrogeological regime, which is specific for the territory;
- salinity and groundwater depth;
- relief of waterproof bed and complicated ground flow;
- limited runoff of the Syrdarya river and development of irrigated agriculture.

Arid climate coupled with drainless area causes all-round salinization of soil. Already positive salt balance of the delta is aggravated by impulverization removal of salts from the dried seabed and their accumulation on the territory of delta.

Both virgin and irrigated hydromorphic soils in Syrdarya delta are characterized by high degree of salinity. They vary from low, heavy and very heavy saline soils, with prevalence of heavy saline soils.

As a result of regulation of the Syrdarya river flow there is a trend to expansion of areas under heavy and very heavy solonchaks. Estimation of areas by salinity of hydromorphic soils in Syrdarya delta was made using data from soil surveys conducted by the State Center for Land Resources and Land-Utilization of the Republic of Kazakhstan in 1996-1997 (Table 1.1.3.1).

Meadow and swampy soils in Syrdarya delta are the main land fund of irrigated agriculture. Therefore, out of 360,2 thousand ha of total hydromorphic soils 79,5 thousand ha (22,1%) are classified as irrigated analogues. However, analysis of irrigated agriculture dynamics allows us to conclude that the highest utilization of lands in irrigated agriculture was in 1985 and was estimated at 34,4 thousand ha (9,6%) of total area of hydromorphic soils, or 43,3% of the area of meadow and swampy family soils classified as irrigated ones.

This is explained by the fact that high salinity of delta soils has negative effect on the state of irrigated schemes. This caused farms to use the tactics of «nomadic» farming, i.e. using new tillable lands for irrigation and thus increasing man-modified such called irrigated analogues of meadow and swampy soils.

At present, solonchak and saline meadow and swampy soils are used for pasturing, though they can by considered as reserve irrigation fund for the region.

Deterioration of water supply to hydromorphic soils in Syrdarya delta has considerable effect on their natural development. Alluvial-meadow and meadow-swampy soils, being transformed through stages of drying off and desertification, are added to area of solonchaks, takyr-like soils and sands.

Periodical flooding of swampy soils in modern delta facilitates their slight desalination but within limited area.

Table 1.1.3.1
Classification of soils in modern delta of the Syrdarya river by degree of salinity

Soils	Kazalinsk rayon, thousand ha					Aralsk rayon, thousand ha				
	non-saline	low saline	medium saline	heavy and very heavy saline	Total	non-saline	low saline	medium saline	heavy and very heavy saline	Total
Alluvial-meadow salty soils	3,0	2,5	0,2	0,7	6,4	0,6	3,6	0,4	-	4,6
Alluvial-meadow salty soils, irrigated	0,8	0,7	2,5	3,7	7,7	-	-	-	-	-
Alluvial-meadow solonchaks	3,1	12,7	9,6	34,5	59,9	-	6,2	17,5	29,2	52,9
Alluvial-meadow tugai soils	-	-	0,135	-	0,135	-	-	0,1	-	0,1
Alluvial-meadow solonchaks, under desertification	2,1	2,0	1,7	6,6	12,4	-	0,9	15,6	19,8	36,3
Alluvial-meadow solonchaks, irrigated	0,4	6,3	13,8	14,9	35,4	-	-	-	-	-
Meadow-swampy solonchaks	0,8	3,0	5,2	25,6	34,6	-	5,0	8,6	23,2	36,8
Meadow-swampy solonchaks, irrigated	6,4	2,9	3,6	6,4	19,3	-	-	-	-	-
Meadow-swampy solonchaks, under desertification	-	0,4	1,9	5,3	7,6	-	0,1	-	8,7	8,9
Swampy soils	4,0	-	0,4	0,3	4,7	-	0,5	-	15,1	15,6
Rice-swampy solonchaks		2,9	6,8	7,4	17,1	-	-	-	-	-
Total area of hydromorphic soils	20,6	33,4	45,84	105,4	205,2	0,6	16,3	42,2	95,9	155,0
%	10,1	16,3	22,3	51,3	100	0,4	10,5	27,2	61,9	100
Meadow solonchaks	-	2,0	4,3	11,4	17,7	-	-	0,8	0,9	1,7
Meadow solonchaks, irrigated	-	0,2	0,5	4,0	4,7	-	-	-	-	-

Soils	Kazalinsk rayon, thousand ha					Aralsk rayon, thousand ha				
	non-saline	low saline	medium saline	heavy and very heavy saline	Total	non-saline	low saline	medium saline	heavy and very heavy saline	Total
Typical solonchaks	-	-	2,8	17,7	20,5	-	-	-	19,9	19,9
Typical solonchaks, irrigated	-	-		0,1	0,1	-	-	-	-	-
Takyr	-	-	-	1,2	1,2				0,5	0,5
Takyr-like	-		0,2	1,7	1,9	-	-	-	5,3	5,3
Total area of semi-hydromorphic soils	-	2,2	7,8	36,1	46,1	-	-	0,8	26,6	27,4
%	-	4,8	16,9	78,3	100	-	-	2,9	97,1	100
Total for delta:	20,6	35,6	53,64	140,3	250,2	0,6	16,3	43,0	119,6	179,5
%	8,2	14,3	21,4	56,1	100	0,3	9,1	24,0	66,6	100

At present, drying-off and salinization of soils are accompanied by intensification of meadow formation processes, by tugai degradation on natural levees, and by expansion - in less scales than in Aralsk rayon - of solonchak, takyr-like and sandy soils.

In nineties in middle reach of the delta (Kazalinsk rayon) desertification and salinization processes become weaker due to improvement of water supply. There is a tendency towards expansion of alluvial-meadow and meadow-swampy soils compared to eighties when ecological situation (complete or almost complete absence of floods and water releases to the delta) was characterized by worst indicators and hydromorphic soils becoming dry on the surface were prevalent.

In lower reach of the delta desertification is the most scaled and the ecological situation is tense. Water supply in the lower reaches (Aralsk rayon) leaves much to be desired, therefore degradation of hydromorphic soils continues, which is evident from full transformation of marshy and swampy soils, prevalence of meadow-swampy and alluvial-meadow soils becoming dry on the surface, with very heavy salinity, and expansion of takyr-like soils, sands and solonchaks. Salinization in southern part of Prearalie grows more progressively compared to that in northern part, as well as compared to Uzbekistan as a whole and to Karakalpakstan.

Unfavorable salt balance throughout the whole territory of Southern Prearalie underlies worse state of lands. Previously the Aral Sea was the main accumulator and collector of salts in the basin, while currently the lower reaches of Syrdarya and Amudarya perform mainly these functions. In particular, from 1980 to 2000 the Amudarya lower reaches accumulated more than 1 million t/year. Unfortunately, such negative environmental impact did not receive response for improving land reclamation measures in Karakalpakstan, Khorezm and Tashouz where general plan of all drainage actions, especially under systematic shortage of water, requires revision against former approaches of Soviet period.

Area of hydromorphic soils reduced from 630 thousand ha in fifties to 80 thousand ha at present. General area of solonchaks has increased to 273 thousand ha (34%) against 85 thousand ha (7%) in 1953. In the future development of sandy-desert, takyr, residual and takyr-like soils is expected. As a result of wind activity humus content decreases from 0,5-0,6% to 3-4%.

1.1.4. Development of aeoline processes and salt-dust transfer from the dried bed of Aral Sea

Activation of the aeoline processes and the transfer of salt and dust from the dried bed to adjacent areas is one of the main criteriaof desertification in Prearalie.

Development of deflation-accumulation and impulverization processes on landscapes of Kazakhstan's Prearalie is predetermined by wind regime in the region, wide light textured soil, low precipitation, poor and sometimes total lack of plant cover [26].

Experimental field studies of Kazakh researchers have demonstrated that average sand removal out of the dried bed reached 7,3 million t/year, of which 0,7-1,5% was salts. Consequently, average long-term salt removal from the dried bed of Kazakh part is 50-70 thousand t/year [27, 28].

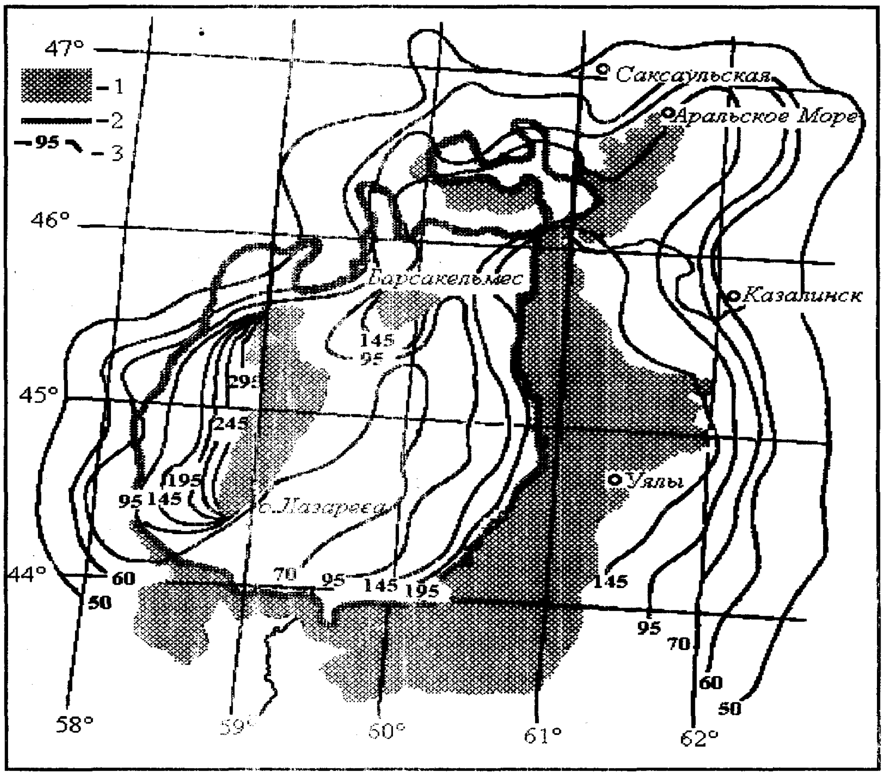
In contrast to these data, Uzbek researchers have obtained another results [30]. In Eastern Prearalie coastal strip receives approximately 1,5 times more particulate pollutants than in southern part of the Aral Sea. In Nothern Prearalie value of particulate pollutants is close to that in the Amudarya delta. The map (Fig. 1.1.4.1) shows that most portion of wind-transferred sandy-salt pollutants falls in immediate proximity to deflation center or at several kilometers far from the source. Tails of heavy storms are up to 200-400 km long on satellite images, i.e. residual mass of particles falls at a distance of few hundreds of kilometers. Only slight portion of smallest particles may be transferred to long distances during very heavy storms.

We have other evaluations of sand and salt transfer from the dried bed as well. Researchers from Leningrad after procession of dust storm satellite images have obtained that annual south-westward transfer of particulate pollutants from eastern center of deflation was 15-75 million t [27[a]]. According to this value intensity of denudation on the dried bed should reach approximately 5-20 mm/year. N.V. Rubano and N.M. Bogdanov [27[a]] have estimated annual wind transfer of salts from the whole dried bed to date at 39-42 million t/year. This value seems to be over-estimated. Thus, if consider, according to Kazakh researchers' estimation, that percentage of salts in wind-sand flow equals 1%, general mass of wind-transferred particulate pollutants should reach about 4 billion t. Deflation layer in this case should be about 0,15 m/year, i.e. dried bed of the sea must deepen at the same rate as the sea level drops. In reality, such intensity of deflation is not observed. Comparison of annual deflation layer indicates that obtained by Kazakh researchers denudation rate is closer to actual one, though, as was already mentioned, it is slightly overestimated. All mentioned estimations indicate that aeoline process taken place on the dried bed is the strong modern geological one to date.

A poll was conducted to get opinion of population in Kazalinsk and Aralsk rayons on the influence of dust and salt transfer from the dried bed. In Aralsk rayon this influence is not felt, while professionals and residents in Kazalinsk rayon indicate to considerable impact of salt and dust transfer. At present, deflation is growing because of breach of Kokaral dam. This became clear during visual examination of Kokaral dam.

According to Kazakh researchers' forecasts [27, 28, 29], average long-term transfer of particulate pollutants is expected to grow by 1,3 million t/year only due to expansion of deflation-risky areas.

The following may be pointed out during estimation based on average indicators of all observation points – first intensity of salt-dust transfer gradually increases and then it decreases and becomes stabilize.



1 - areas of the dried seabed; 2 - current shoreline; 3 - particulate pollutant isolines

Fig.1.1.4.1. Average long-term value of total particulate pollutants in Kazakhstan's part of Prearalie, brought by storm tails and convective lifting of particles from surface (t/km^3/year) (KazNIIMOSK's data)

1.2. Environmental changes

Degradation of natural complexes in Kazakhstan's Prearalie results from imbalance between the resource capacity of environmental elements and the scales of their economic utilization. Disturbance of ecological balance led to continuous sea level drop. In turn, the Aral Sea, which undergoes qualitative and quantitative changes, exerts negative influence on adjacent territories.

1.2.1. Loss of the Aral Sea as the natural object

There exist indications that level of the Aral Sea changes as a result of climatic and other natural cycles. It is supposed that considerable increase, since 1913, in withdrawal of river waters was balanced by positive changes in such fluctuations. However, it is clear that since 1961 withdrawal of water for meeting needs of expanded irrigated agriculture, both for crop irrigation and land leaching has caused fatal environmental imbalance in the Aral Sea basin. This was a spur to widely known environmental disaster as the Aral Sea crisis.

Quantitative assessment of the role of anthropogenic factor in modern changes of the Aral Sea regime was made through calculation of level and salinity values over 1961-1980 on a basis of relatively natural inflow to the sea. As calculations showed, more than 70% of current drop in level and increase in salinity was caused by anthropogenic factor, while the rest is promoted by climatic factors, such as natural shortage of water during this period.

The main consequence of the sea shrinkage, besides reduction of volume and surface, and changes in salinity patterns, is revealed in occurrence, on the dried bed, of a large desert, which currently spreads to 3,6 million ha. As a result, the unique freshwater body was replaced by vast bitter-saline lake together with colossal salty desert, at junction of three sandy deserts.

In 1985-1986, southern part of the sea (Small sea) completely separated from the northern part (Big sea) at an absolute altitude of 41 m. This resulted in occurrence of new desert zone within an area of 6000 km^2, with reserve of salts in upper layer of up to 1 billion t. Currently, saturated gypsum solution falls out of seawater. When sea level falls to 30 m of absolute altitude (by 23 m) western part of deep Big sea will separate, in form of islands, from eastern shallow part.

After separation of two seas their regimes started to develop by different scenarios. Since inflow from the Syrdarya river is higher last years than that from the Amudarya river, level of Small sea rises and its salinity decreases. Break of temporal dam at Small sea caused fall of its level, however previous filling indicated to adequacy of the decision to create separate water body of Small sea at an altitude of 41-42,5 m.

Drop of the Aral Sea level reached about 20 m (Big sea) and about 14 m (Small sea), shoreline receded to a distance of 130 km, while water volume reduced by more than 70% from 1960 to 2000 and surface area decreased from 68 thousand km^2 to 23 thousand km^2. In consequence of the shrinkage and other factors considered below, water salinity increased from 10 g/l in 1965 to 58 g/l (Big sea) and 28 g/l (Small sea) in 2002. Water quality changes considerably to the worse due to other types of pollution. Pollution and alkalinization of the Aral Sea have led - in mid seventies - to death of sea inhabitants. When sea salinity exceeded 14 g/l, biomass and number of phytoplankton decreased 3-5 times. As a result, growth rates became slower, death rate increased and reproduction processes completely broke in respect to many fishes.

Before 1960, the Aral Sea and connected lakes hade provided on average 25 000 t/year of fish. This laid a basis for creation of sustainable fish industry, with fish processing and fish cannery plants in Aralsk and Muynak. In general this industry had provided 60000 workplaces.

Environmental changes affected various animal and bird groups and species, particularly those whose habitat is related with aquatic biota. For instance, in 1964 production of musquash amounted to 2 million specimens, while in 1990-1992 it reached only few tens and by now it has disappeared at all. In eastern Prearalie number of nesting birds species decreased from 160 to 32, and most of waterfowl and coastal birds migrated northward (400-500 km) to Tengiz lakes.

Degradation of resource capacity of the Aral Sea has taken on irreversible trend and conservation and restoration of this capacity is hardly possible in near future. Disastrous drop of the sea level, reduction of water mass, and increase of salinity have led to loss of its biodiversity. Changes in basic chemical and physical characteristics of aquatic habitat had already caused three-fold reduction of microorganisms in Small sea and the north of Big sea by 1990.

In nearest future, the Aral Sea will exist in form of few separate inland water bodies, with individual level regimes depending on strategies being chosen by five republics.

1.2.2. Plant cover changes in Prearalie

Background and current state of plant cover in Eastern Prearalie is shown in Table 5 (Kazakh researchers' data [31, 32, 33, 34, 35, 36].

Table 1.2.2.1, based on publication sources [33, 34, 35], shows dynamics of the occurrence of dominant flora composition in Syrdarya lower reaches and allows us to note structural transformation of delta's flora towards the decrease of tree-bush mesophytic forms and their replacement by halophytic and xerophytic bushes. Reduction of grains and motley grass and increase of halophytic and xerophytic Russian thistle and weeds are observed as well.

Analysis of published data shows that in early sixties floodplain and inter-channel sinks in Syrdarya were covered by grass, including Phragmites australis, Calamagrostis epigeios, Hordeum bogdanii, Agropyron repens, Aeluropus litoralis, Glycyrrhiza glabra on meadow-swampy and alluvial-meadow soils. About 55% of meadow vegetation was reed hayfields (Phragmites australis) yielding 20-60 c/ha.

At present time, as a result of changed hydrological regime and over-moving qualitative transformation of plant associations took place and floodplain meadows turned out to be on the verge of disappearance. Since 1960, area of reed hayfields has reduced 6-7 times, and their yields have decreased to level of those produced by pastures located in watershed valleys (Fig. 1.2.2.1). Areas of licorice and grain-motley grass associations have been reduced everywhere by 70-75%.

Table 1.2.2.1
Occurrence of dominant flora composition in Syrdarya lower reaches

Plant species	Species occurrence			Plant species	Species occurrence		
	1960	1980	2000		1960	1980	2000
Trees and bushes				**Subshrubs and motley grass**			
Salix caspica	4	2	1	*Glycyrrhiza glabra*	3	1	1
Salix. Songarica	3	3	2	*Trifolium repens*	2	-	1
Salix alba	4	2	1	*Alchagi pseudoalchagi*	4	2	2
Populus pruinos	2	1	1	*Melilotus albus*	3	1	1
Populus diversifolia	3	2	1	*Medicago falcate*	2	-	1
Populus arianae	1			*Climacoptera brachiata*	2	3	4
Halimodendron halo-dendron	5	3	3	*Kochia prostrata*	2	3	3
Elatagnus oxycarpa	4	5	5	*Limonium gmelenii*	2	4	4
Tamarix ramosissima	2	3	4	*Karelinia caspica*	1	4	3
Tamarix hispida	2	4	5	*Apocynum lancifolium*	3	1	1
Halohylon aphyllum	4	2	1	*Typha angustifolia*	4	1	1
Atraphaxis spinosa	4	2	2	*Bidens tripartite*	2	1	1
Nitraria Schoberi	1	4	3	*Inula caspica*	3	1	1
Grains and sedge				*Lythrum salicaria*	3	2	1
Leymus multicaulis	5	1	2	*Anabasis ahylla*	2	4	4
Phragmites australis,	5	2	3	*Anabasis salsa*	1	2	3
Calamagrostis epigeios	5	2	2	*Butomus umbellatus*	3	1	2
Lasiagrostis splendens	4	1	1	*Halocnemum strobi-laceum*	2	3	4
Elytrigia repens	3	4	4	*Saussurea salsa*	1	3	3
Aeluropus litoralis	2	3	3	*Atriplex tatarica*	2	3	2
Poa pratensis	4	2	1	*Clematis orientalis*	3	1	1
Bolboshoenus mari-timus	4	1	2	*Xanthium strumarium*	1	4	3

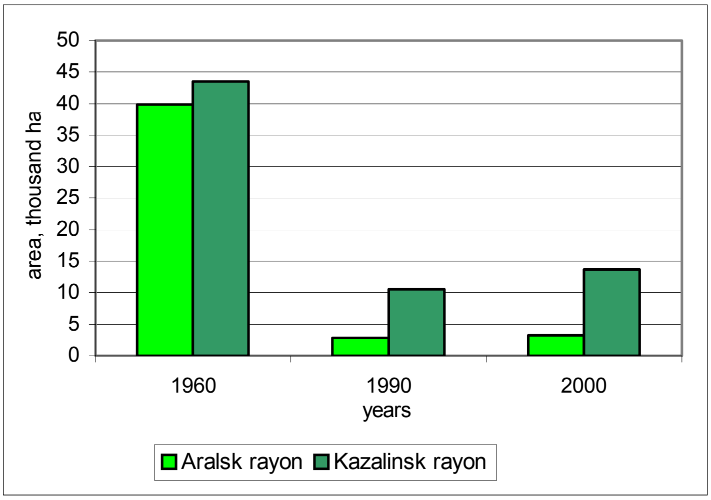


Fig.1.2.2.1 Changes in reed hayfields

Tugai forests make vegetation in Syrdarya delta peculiar. Tugais in Aralsk and Kazalinsk rayons are timed to floodplain terraces and natural levees and spread along banks of the Syrdarya river and its distributaries at a width from 300 m to 3 km. Tugais were related to alluvial-meadow soils, with groundwater level of 1-3 m, and created specific river microclimate by decreasing temperature and increasing humidity. Trees and bushes of tugais were comprised of loeaster (Elaeagnus oxycarpa), poplar (Populus pruinosa P.diversifolia), willow (Salix,caspica, S. songarica, S.alba), chingil in some places (Halimodendron halodendron) and tamarix (Tamarix ramosissima) [54]. Areas between some plots of tugais were occupied by grain and motley grass (Calamagrostis epigeius, Agropyron repens, Eremopyrum orientale, Lasiagrostis splendens, Lysrum salicaria, Glycyrrhiza glabra, Apocynum lancyfolium, Alisma plantago). Thus, in sixties 21,3 thousand ha were covered by tugai vegetation.

Regulation of flow and change of hydrological regime has led to changes in flood periods from June-August to April-June and sometimes to flood loss. This in turn has caused breach of seed reproduction conditions for dominant tugai plants on alluvial banks, while from the other hand general fall of groundwater level and changes in groundwater salinity have contributed to structural transformation and mixture of tugai and delta ecosystem floras. In 1980, groundwater level fell to 4-6 m and 2800 ha under osiers and loeaster-willow tugais dried out in Kazalinsk rayon [37].

Nowadays tugai area has reduced almost 20 times and reached 0,3 thousand ha in Aralsk rayon and 0,9 thousand ha in Kazalinsk rayon. Natural levees are covered by low-yielding Russian thistle (Salsola nitraria, Anabasis aphylla, Girgensohnia oppositiflora, Climacoptera brachiata), grain and weed associations (Aeluropus litoralis, Agropyron repens, Goebelia alopecuroides, Dodartia orientalis, Anabasis aphylla, Acroptilon repens, Descurainia sophia, Pluchea caspica); bush tier is shown by general increase of tamarix on solonchak meadow soils and of chingil on deserted alluvial meadow soils (Table 6). The change in hydrological regime and alkalinization caused rise of halophytic vegetation on meadow solonchaks and typical solonchaks from 26 thousand ha in 1960 to 80 thousand ha in 2000. Tamarix associations extended most of all from 4 thousand ha in 1960 to 22,2 thousand ha in 2000.

General dynamics of vegetation in Syrdarya delta is shown in Figure 1.2.2.2.

From 1992 to 2000 irrigated area reduced almost two-fold in Kazalinsk rayon. Halophyte-weed associations are formed on fallow lands due to lack of flooding.

Thus, changes in hydrological regime and drying of the delta under pressure have led to significant changes in the Syrdarya delta. Indigenous pastures have reduced by 47%, area of hayfields have fallen almost three-fold, from 21,3 thousand ha to 1,2 thousand ha, indigenous tugai ecosystems have decreased, and areas under secondary and halophytic associations have increased almost 4,7 times.

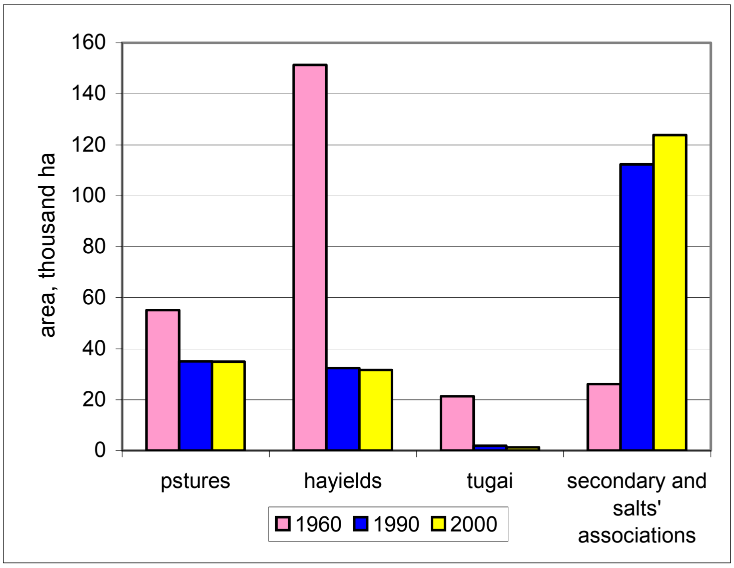


Fig. 1.2.2.2 Vegetation structure in Syrdarya delta

To compare let us show figures of Uzbek researchers, such as S.U. Treshkin and others [38]. Areas reduced from 600 thousand ha (60-ties) to100 thousand ha (end of 70-ties) for reed vegetation, from 1300 thousand ha to 50 thousand ha for tugais, from 420 thousand ha to 75 thousand ha for hayfields, and from 728 thousand ha to 145 thousand ha for pastures.

1.2.3. Climate change

Issue of basic climatic parameters changing in coastal area has been highlighted enough broadly in scientific bibliography [40, 41, 42, 43, 44, 45]. Authors of considered papers give quantitative indicators of wind and temperature-humidity regime variation in region.

Aral Sea impact on climatic background of Prearalie before level lowering had been local and tracked enough clearly. O.M. Zhitomirskaya and I.I. Prokhorov [40, 41] have identified substantial mitigation of climate aridity on Aral Sea coastal zone at distance 150-200 km, in winter period the air temperature in this zone was on 1-2 ^{o} C higher than on terrestrial weather stations, and in summer on 1-3 ^{o}C lower.

Continuous lowering of the Aral Sea level for recent years has also caused climate change in Prearalie. Field experiments on microclimatic parameters on dried seabed, carried out by Institute of Geography at MON RK, showed that anthropogenic desertification results in obvious changing of microclimatic parameters. Leveling of microclimatic differences in various natural complexes of dried Aral Sea part and bedrock bank, in view of underlying top soil, as well as change of hydrological and hydrogeological regimes. All this results in imbalance of existing before ratio of heat balance components [46]. It was determined that increase of areas with aeoline type of relief, without any vegetation, promotes temperature regime increase as well as aridity increase in warm season. Natural complexes with projective vegetation cover up to 40-60% in summer period decrease air temperature at altitude 0.3 m on 1,3 ^{o}C, and at altitude 2 m – on 0,7 ^{o}C. Maximal difference in temperature between natural complexes of the first year of existence in continental regime absolutely without vegetation and natural complexes of bedrock bank with wormwood vegetation is 8-10 ^{o} C. Relative humidity difference for above mentioned natural complexes is 60-70% [47].

Field aerosol emission to atmosphere has led to reduction of its transparency from 0,756 to 0,68 (April) and from 0,74 to 0,69 (July) and caused redistribution of flows of solar and back-scattered radiation. Aral Sea heat reserve reduced on 54% (average annual) and 93% (winter) that broke traditional processes of heat and moisture exchange with atmosphere and, finally, increased contrast between summer and winter temperatures, reduced non-frost period as well as air humidity. Thus, in north coastal zone air humidity in June-August reduced on 25-30%, in Syrdarya River delta and in Kazalinsk city area – on 15-20%, air temperature in summer increased on 0,5-0,7 ^{0}C. In whole coastal zone, except Aralsk region, in warm time wind speed decreased on 0,5-1,0 m/s, however maximal speeds increased on 4-5 m/s. Climatic conditions changing is noted in coastal zone up to 100 km.

One of the indicators of Aral Sea level lowering impact on variation of climatic characteristics is change of thermal regime in sea adjacent areas. In coastal zones during “anthropogenic period” air temperatures increased on 1,1-1,7^{o}C in winter, in spring – on 1,6-3^{o}C, and in summer – on 1,8-2,4^{o}C, according to data of “Uyaly” weather station, and on 2,5-3^{o}C, 0,9-3,0^{o}C, 1,1-1,5^{o}C appropriately, according to “Aral Sea” station.

On continental stations (“Saksaulskaya”, “Monsyr”, “Kazalinsk”) also increase of November, December, and January temperatures on 1,2-2,2^{o}C, April – on 1,5-1,7^{o}C, and summer temperatures – on average on 0,7-0,9^{o}C can be observed (figures 1.2.3.1, 1.2.3.2). G.N. Chichasov et al. [49] explains that April and summer temperatures increase on continental stations didn’t occur in result of sea level lowering, but due to effect of long period fluctuations of thermal regime.

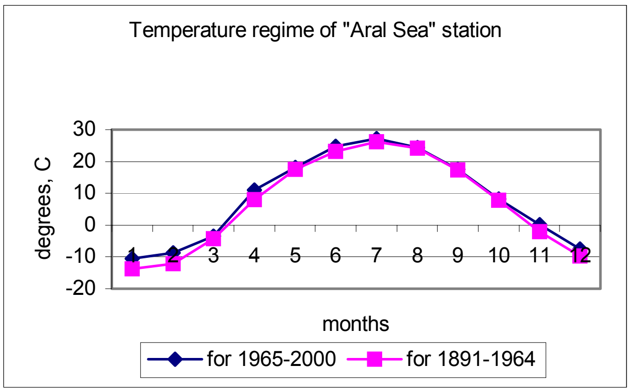


Fig. 1.2.3.1

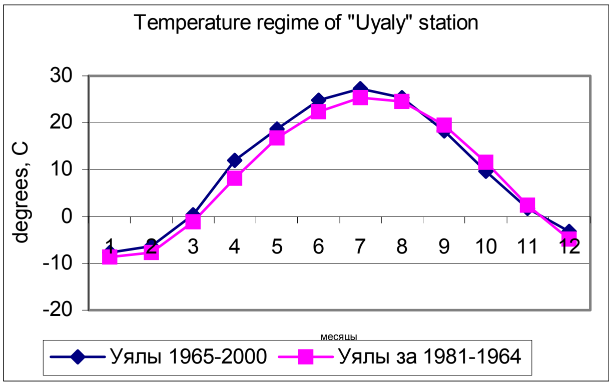


Fig.1.2.3.2

Analysis of average monthly values of air humidity over coastal and continental stations for anthropogenic period and of air humidity for period before sea level lowering proves climate aridity increase in Aral Sea zone and confirms results published earlier [52, 53].

Air humidity change occurs only in coastal zone. So average monthly air humidity curves for both periods on “Saksaulskaya” station located in 35-40 km from bedrock bank of Aral Sea (Figure 1.2.3.3) practically coincide.

Analogous scene is observed on “Kazalinsk” station located in 70 km to the east from Aral Sea. Insignificant (on 2-3%) reduction of air humidity during anthropogenic period in summer, probably, is connected with reduction of Syrdarya becoming shallow as well as decrease of local moistening effect.

Relative humidity on “Aral Sea” coastal station located on north-east of the sea from 1965 to 2000 years has being reduced for warm period of the year on 4-8%, in fall-winter period air humidity has remained almost the same. This can be explained by that in winter period the sea is often frozen, and its moistening effect is low.

Absolutely different picture of relative humidity changing can be observed in zone of “Uyaly” station (Figure 1.2.3.4), which up to 1980 was insular one. Before sea level decrease on the island during all year relative humidity had exceeded humidity indicators of other stations sufficiently. During “anthropogenic period” relative humidity on “Uyaly” station has decreased in spring on 8-10%, in summer – on 9-12%, and in fall-winter – on 3-6% against conditional-natural period and in general became approximate to humidity of weather stations, which didn’t experience Aral Sea impact.

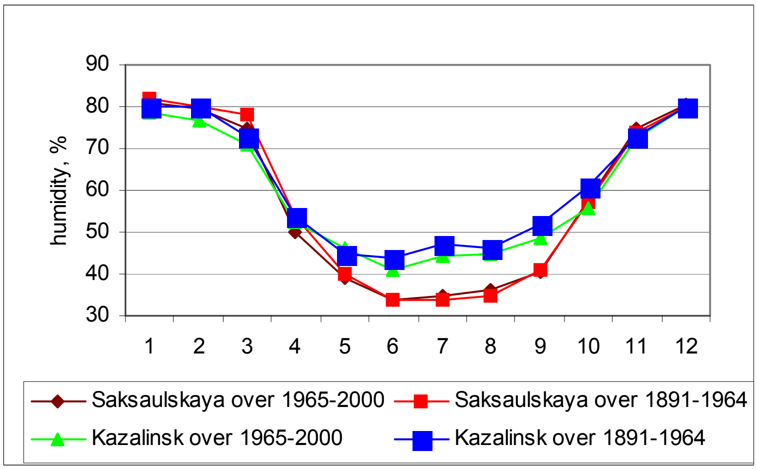


Fig. 1.2.3.3 Relative air humidity variation over stations «Saksaulskaya», «Kazalinsk»

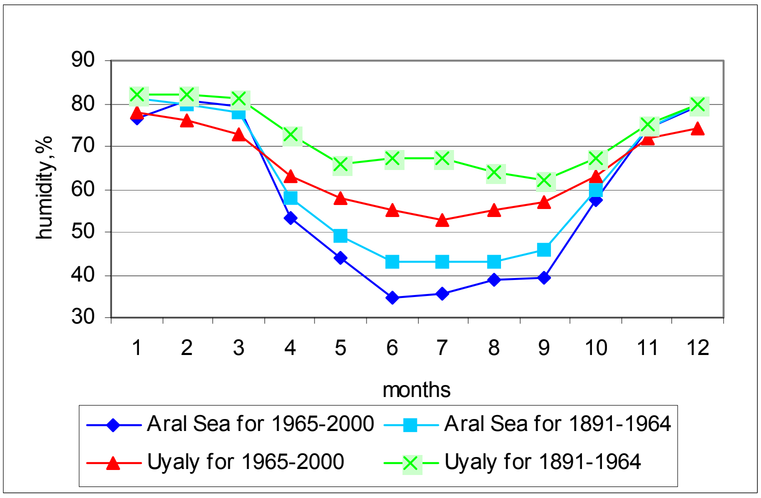


Fig. 1.2.3.4 Relative humidity variation over stations «Aral Sea», «Uyaly»

Analysis of multiyear average annual precipitation sums for anthropogenic and conditional-natural periods didn't allow identifying regularity of Aral Sea level lowering impact on precipitation change. G.N. Chichasov [52] counts that atmosphere precipitation are subjected to cyclical fluctuations, therefore to determine changes of moistening extent it is important to know on which branch of cycle analyzed years can be found.

In connection with increase of silt-salt particles removal amount from dried Aral Sea part wind regime directness and tendencies of its changing in result of sea surface area is very important. According to data of G.N. Chichasov [52] for northern Prearalie in warm period of the year tendency of increasing repeatability of north-eastern winds can be noted, for eastern Prearalie increase of western and north-western winds repeatability is typical as well as reduction of breezes influencing coast microclimate.

Analysis of average annual wind speed variation from 1961 to 2000 years showed significant wind speeds changes towards their reduction on 1-1.5 m/s for continental stations "Kazalinsk", "Monsyr", and "Saksaulskaya".

As for "Uyaly" station, which since 1980 stopped to be insular, wind speed reduction on 1.5-2.0 m/s can be observed. On "Aral Sea" station insignificant wind speed reduction is noted (Figure1.2.3.5). Probably, wind speed decrease is caused by width of dried sea part. Increase of uneven bare surface reduces wind speed.

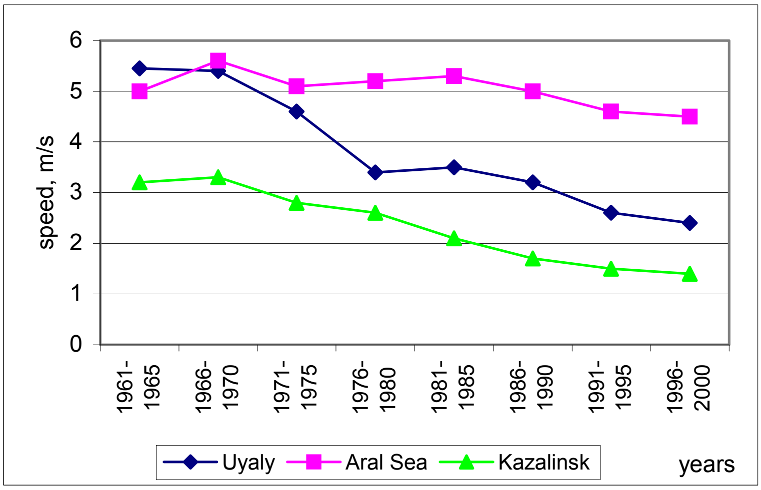


Fig. 1.2.3.5 Average annual wind speed change

Aral Sea level decrease effects local climate change in coastal zone of not more 50-100 km wide. Tendency of summer temperatures increasing as well as relative humidity decrease in spring-summer period in 30-km zone, and wind speed reduction can be observed.

Climate change in South Prearalie is characterized by sufficient local climate change. Microclimate changes [43, 44, 45] within few dozens kilometers from reduction of former sea level of 1960. These changes intensified in process of offshore shifting on 40-60 km. Then it was difficult to identify their further influence. Average summer air temperature increased on $0,1^0$-$0,4^0$ C, spring – on $0,5^0$-$0,7^0$ C. Winter and fall temperatures lowered on $0,2^0$-$0,6^0$ C and $0,5^0$-$1,3^0$ C appropriately. Daylight amplitude of temperatures in coastal zone increased, and relative air humidity reduced, in particular in warm period of the year.

Increase of dust storms quantity can be observed with maximum in April-July. Local climate transformation on dried sea area was followed by increasing frequency of sunny and very hot days on 15%, and frequency of sunny wet days reduced 4 times. In general frequency of weather unfavorable for human activity increased.

1.2.4 Salt and dust transportation impact on changing of natural and agricultural lands' productivity

According to KazNIIMOK data in Prearalie, in coastal zone, up to 7.3 mln. t/year of salt and dust aerosols occur [48]. To obtain qualitative indicators of natural and cultural crop productivity is impossible because of lack of quantitative and exact methodical developments and instrumental regime observations. Studies of G.N. Chichasov [49] are the most completed; he has analyzed multiyear course of pasture vegetation yield capacity differences on "Monsyr" station and on stations "Ayakkum" and "Taup" (Fig.11.3).

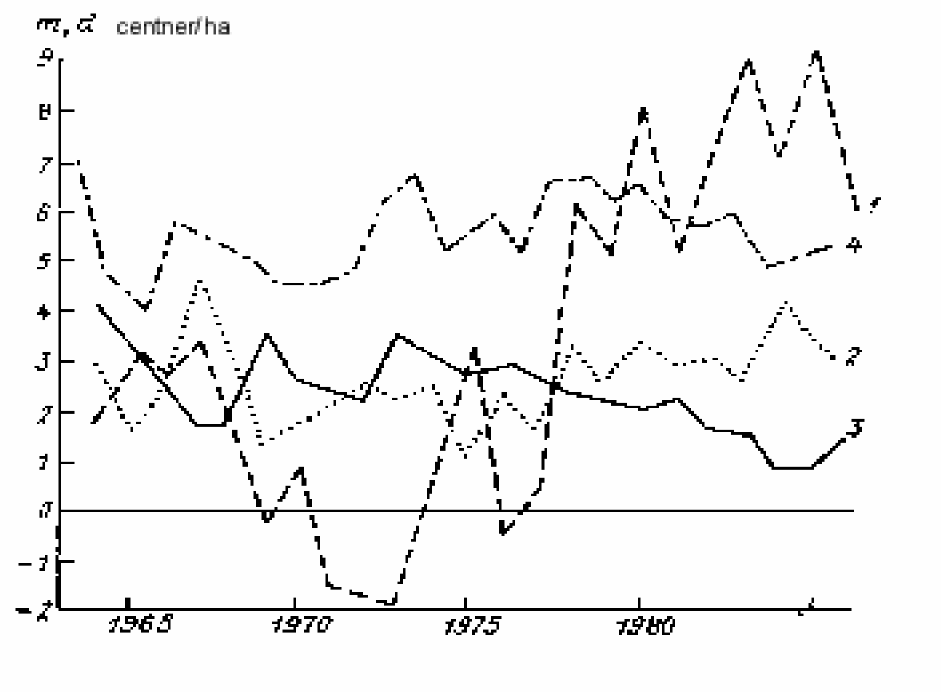


Fig. 11.3. Pasture vegetation yield capacity (m) on stations "Monsyr" (3) and "Taup" (4) and yield capacity difference (d) between stations "Ayakkum" and "Monsyr" (I) and "Taup" and "Monsyr" (2) in the second decade of July

North Prearalie area, were station data are located, is characterized by that that water-table here is at depth more 25-30 m. In connection with that pasture crop yield forms only at the expense of rainfalls. Air humidity also is not crucial, since already at distance about few dozens kilometers from coast it differs on the bank just on 2-3%. This assumes that available pastures' productivity and cropping pattern almost don't change even after absolute Aral Sea vanishing [55]. Perhaps, it could be so, if there was no negative effect of salt and dust transportation from drying part of seabed. However, the figure shows that crop yield capacity difference changes sufficiently in time. Approximately to 1980 its changes were casual, in any case it is not so easy to determine directed compound in this period. During next years increase of this difference can be tracked already rather clearly. "Ayakkum" station is located in the west from main source of salt removal, therefore impact of sand and salt transportation in given region hasn't reached those critical scales yet, when decrease of yield capacity difference between stations "Monsyr" and "Ayakkum" occurs. It is well-known that salty dust is often transferred to the west of Prearalie, however intensity of this process comparing to other processes directed to eastern regions, where "Monsyr" station is located, is not so high because of long distances from the source. Salt transfer impact on multiyear difference of pasture crop yield capacity between stations "Taup" and "Monsyr" more or less clearly manifested after 1975.

Visual observations, carried out by Kazakh Institute of Geography in 1980 on the Aral region pastures in tract Maydakul and Kzylkum, allowed to establish fact of vegetation covering with layer of salt and dust of thickness 2-3 mm. This led to decrease of fodder quality and live-stock intestine diseases.

Salt and dust transfer impact on decline of natural and artificial landscapes' productivity in South Prearalie is characterized in following way:

- cotton damage is 9-11% on bowls and 25% on flowers;
- rice damage is very small;
- fruits damage is 10-15%;
- pasture damage is within 10%.

1.2.5. Birds population change

More 300 species of bird including nesting species – 173, migratory – 123, casual – 23 populated Aral Sea coastal zone as well as Syrdarya delta. The most numerous representatives belonged to anserine family (swans, geese, ducks), snipes, seagulls, water rails, waders, etc. Colonies of pelicans, cormorants, herons, terns (50) were not rear phenomena. With delta watering reducing and Aral Sea level lowering ornithofauna of Kazakh Prearalie has lost about 70 bird species. Simultaneously new category emerged – synantrops, populating cultivated landscapes and living near by man.

1.2.6. Change of Aral Sea and reservoirs fish productivity

Once Aral Sea was considered as the third in size fish-husbandry reservoir in USSR. If in 50-60-ties it gave 40-50 th.t., by the end of 60-ties fish catches reduced to 10-9 th.t, in 1980 – they didn't exceed 2.5 th.t. About 50% of fish catches belonged to North Aral Sea. Aral Sea ichthiofauna consisted of 20 fish species, but only bream, carp, vobla, shemaja, barbel, pike perch, and zherech have commercial value, they constituted 80% of total fish catch. Since 1988 the sea lost its fish-husbandry significance. In the middle of 70-ties works on acclimatization of euryhaline and salt-loving fish species, such as Caspian sturgeon, Kuril salmon, oriental kizhuch, Black Sea-Azov plaice-gloss, and plaice-kalkan, were started. Adaptation ability of these fishes was low because of annually changing water-salt regime of the sea. Plaice-gloss became the most favorable fish specie, because it differed with high plasticity, reproducing in wide range of seawater salinity – from 17% to 60%. Presently Small Sea ichthiofauna present acclimatizing fish species: bullhead, atherina, Baltic herring, and plaice-gloss. In result of experimental-industrial fishing it was caught: in 1991 – 51 t, 1992 – 116 t, 1993 – 55 t, 1994-95 fishing was not fulfilled, 1996 – 155.5 t, 1997 – 337 t, 1998 – 107.3 t, 1999 – 19.6 t of plaice fish (51) (Fig.1.2.6.1).

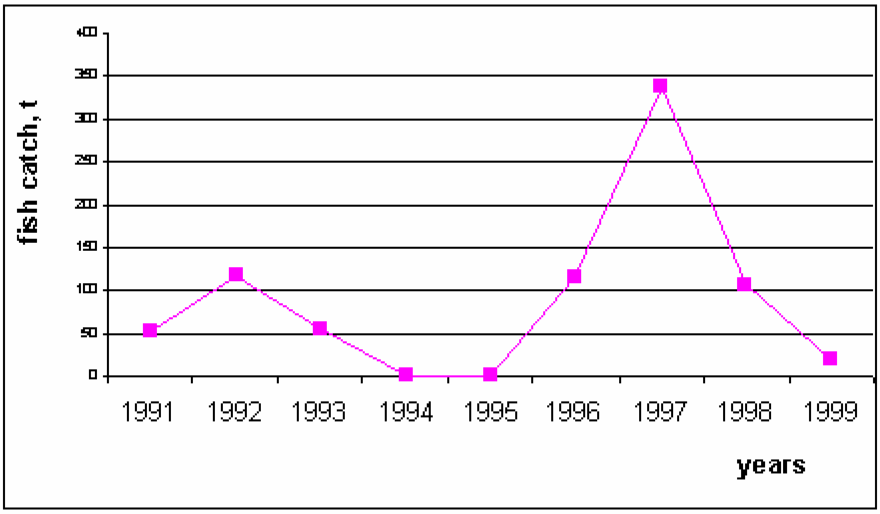


Fig.1.2.6.1. Fish catch dynamics

Aral Sea and Syrdaraya delta lake systems served as fish product source for local population needs. Their ichthiofauna was presented by 21 fish species. Amount of caught fish in lake systems varied from 21.3 th.t (1960) to 9.4 th.t (1969). In 1972 fish catch amount increased to 11.5 th.t, but by the end of 90-ties it declined to 2.4 th.t.

To reproduce and increase fish productivity of Syrdarya River delta lake systems number of fish-breeding farms with total area 4.3 th.ha, which are private now, were created, therefore presently it is practically impossible to control fish catch.

In South Prearalie since 1960 fish-breeding intensively transited from the sea to reservoirs of Prearalie, mainly on base of exporting from Far East of fish species (mirror carp, grassy carp) and only 14% of local species. Nevertheless, even after development of lake fish-breeding amount of fish reduced ten times.

1.2.7. Conclusion to the Chapter I

Analysis of research work results, bibliographic data review as well as questioning of experts and local population conducted during visits to two regions (Kazalinsk and Aralsk) allowed to carry out assessment of environmental state and identify prior environmental problems in Kazakh part of Prearalie.

Sea level and its size varied in history many times. It has been proved by found terraces at altitude 56,5; 54,5; 43,5; 40,5; 35,0 m and analysis of silt and salt sedimentation. Till the beginning of 60-ties river water inflow to the sea and its regime remain relatively stable. Time period from the initiation of systematic instrumental observations of sea level and other sea regime properties (1911) till 60-ties can be defined as conditional-natural. Present life period of the sea since 1961-98 significant evaporation exceeding sum of inflow compounds is typical. River water inflow was in 1961-1998 years 53% of average long-term inflow, observed in period 1911-1960 (53 km^3), for 1971-1980 – 30%, for 1981-1990 – 6%, and in period 1991-1999 – 13% of average long-term inflow. In some low water years Amudarya and Syrdarya flow didn't reach the sea practically. River flow quality has changed. Increase of strongly saline waste and drainage waters share in this flow resulted in significant salinity increase and aggravation of river water sanitary state. In result of substantial decline of sea level its area for 1961-1985 reduced approximately on 22.3 th.km^2, and volume capacity – on 618 km^3. Offshore changed sufficiently, especially in low water eastern, south-eastern, and southern sea regions. More 70% of present sea level lowering and its salinity increase is caused by anthropogenic factor impact, and the rest part of these changes is climatic factors influence– natural period low water availability. Main consequences of Aral Sea desiccation, beside reduction of volume capacity, surface area, growth and variation of salinity character, manifested in formation of vast salt desert with area almost 3.6 mln.ha in place of dried seabed. Finally unique freshwater reservoir transformed to enormous bitter-salt lake in combination with vast salt desert in conjunction of three sand deserts. In 1985-86 under altitude 41 m full separation of Small Sea from the Big one occurred. This led to formation of new desert area equaled to 6000 km^2 with salt reserve in top layer up to 1 bln. tons. So Aral Sea, being single reservoir in past, soon will transform to range of separated reservoirs with own water-salt balance and own future depending on that what line will 5 countries choose regarding this problem.

Government of Kazakhstan and local self-governance bodies are taking cardinal measures on reducing environmental crisis in Kazakh part of Prearalie. In particular, in 1975-76 due to construction of Amanatkul and Aklak Waterworks as well as later in 1998 Kokaral dam construction some environment stresses were removed in North Prearalie. But, unfortunately, after Kokara dam breach in 1999 and Aklak Waterworks breach in 2002 all rehabilitated earlier ecosystems were going to disappear. Subsequent decline of water horizon in river results in that significant portion of water accumulated in lake systems flows back into the river and goes away to the sea. Water inflow decline to delta reduced watering of all delta lakes in river floodplain, it is going to stop existence of ecosystems, extremely sharpened social-economic and environmental problems of region.

In present situation in Syrdarya River delta and in Prearalie in general unsustainable environmental situations will sustain:

Specific issues of Northern Prearalie are following:

1. Lack of management in Syrdarya delta – there is no water account on its allocation as well as no management mechanism.
2. Ongoing intensive development of desertification of Prearalie surrounding areas.
3. Extremely low flow amount of Syrdarya River coming to delta and Aral Sea that resulted in cessation of delta watering (it is required in the end of April – beginning of May 1.5-2 km3) and sea level lowered more than on16 m against 1994 that, in its turn, caused decrease of Syrdarya erosion basis on 30-50 km site form 1 m (site Aklak) to 15 m in mouth, water-table decrease, delta drying, sea salinity increase, aggravation of climatic region conditions.
4. Cessation of delta flooding by flood waters, Aral Sea leaving bedrock bank more than on 100 km caused reduction of fish lakes area 4 times (1957-97), fish catches from 9-10 th.t to 20 t, area of flood meadows 3 times in Kazalinsk rayon and 10 times in Aralsk rayon, productivity of hayfields and pastures reduced.
5. Degradation of the most valuable in economic meaning meadow soils occurs, which means drying up and salinization. Area of alluvial-meadow soils declined from 20% in 1955 to 12% in 1997 of total delta area, wetlands – from 52.6 to 25%, solonchak area increased from 21.2 to 40%.
6. Main sources of wind erosion are located in Big Sarishaganak bay and between Syrdarya mouth and Akpetki archipelago. Total removal of solid sediments is 7.3 mln t/year, from them appropriately 1.5 and 5.8 mln t, from that 0.7-1.5% is salt (50-70 th.t/year). Zone of increased impact of sand-salt storms reaches 30-50 km from removal sources, general impact extends to 300-500 km.
7. Field aerosol emission to atmosphere caused reduction of its transparency from 0.756 to 0.68 (April) and from 0.74 to 0.69 (July) and led to redistribution of flows of solar and back-scattered radiation. Aral Sea heat reserve reduced on 54% (average annual) and 93% (winter) that broke traditional processes of heat and moisture exchange with atmosphere and, finally, increased contrast between summer and winter temperatures, reduced non-frost period as well as air humidity. Thus, in north coastal zone air humidity in June-August reduced on 25-30%, in Syrdarya River delta and in Kazalinsk city area – on 15-20%, air temperature in summer increased on 0,5-0,7 ^{0}C. In whole coastal zone, except Aralsk region, in warm time wind speed decreased on 0,5-1,0 m/s, however maximal speeds increased on 4-5 m/s. Climatic conditions changing is noted in coastal zone up to 100 km.
8. Change of environmental situation reflected on existence of various groups and species of animals and birds, in particular those, which life is related with water biotas.
9. Aralsk city transformed almost from the port to the continental city, fishing fleet and fish processing enterprises do not function practically (presently they transformed to car-repair plant). Social tension emerged.
10. It is observed that the flow coming downstream is highly polluted with salts, biogenic and organic substances, pesticides that leads to soil salinity, aggravation of hydrobionts life conditions in the river, lake and the sea, impossibility to use river water for drinking needs.

11. Economic and social-hygienic problems related agriculture, non-permitted water withdrawals, intensive rice crop rotation, low water supply level of population with proper potable water, lack of sewerage in settlements, emergency uncontrolled releases, irrational nutrition, shortage of hospitals, schools, and in recent years unemployment, emerged.
12. Simultaneously in region there is problem connected with transboundary character of Syrdarya. As a rule downstream areas suffer from this situation. Within basin limits Kazakhstan, and there – Ksylorda oblast, turned out in the most unfavorable conditions. Violation is expressed as change of schedule of releases, pollution, and under-water supply for agricultural needs. So Kirgiziya accumulates summer Naryn flow to provide optimal regime of Toktogul hydropower operation in winter period that contradicts irrigation demands. In result water inflow in growing period reduced more else, while in cold season releases are carried out in big volumes, major portion of which comes to Syrdarya channels, not giving desirable social-economic and environmental effect.

II. DINAMICS OF SOCIO-ECONOMIC LOSSES INCLUCED BY THE ARAL SEA SHRINKAGE

2.1. Direct economic losses

2.1.1. Irrigated farming

Main specific feature of agricultural lands in Kazakh Prearalie is their location in Syrdarya delta. Analysis of dynamics of agricultural areas showed their instability due to desertification processes activation (erosion, deflation, salinization, pastures degradation, etc.). Pastures prevail over irrigated areas: Aral rayon (99.7%), Kazalinsk rayon (97.3%).

Irrigated lands mostly located in Kazalinsk rayon (99% of all irrigated lands). Reclamation conditions are unfavorable for farming and need drainage and leaching. Since 1985 till 2001agricultural lands area reduced by 1.7 times at expense of arable lands, pastures and hay-cuts; in Aral rayon agricultural lands area increased by 1.18 times at the same time.

Table 2.1.1.1
Dynamics of irrigated lands area change in Kazakh Prearalie, th. ha

Zone	Name	1960	1970	1975	1980	1990	1995	1997	2001
Aral rayon	Irrigated lands availability	1	1	1.3	2.1	3.1	3.1	3.1	1.2
	Irrigated lands use	0.5	0	0	0	3	0.8	0.8	0.7
Kazalinsk rayon	Irrigated lands availability	15.4	15.9	18.8	33.5	34.5	34.5	34.5	33.2
	Irrigated lands use	13.3	14.3	18.8	30.2	32	27.1	16.5	12.8
Kazakh Prearalie	Irrigated lands availability	16.4	16.9	20.1	35.6	37.6	37.6	37.6	34.4
	Irrigated lands use	13.8	14.3	18.8	30.2	35	27.9	17.3	16
Kyzyl-Orda oblast	Irrigated lands availability	104.7	139.7	179.6	246.6	286	286	286	277.7
	Irrigated lands use	92.2	124.6	171	228.5	254.8	231.5	142.5	147.5
	Percentage of irrigated lands use in mentioned rayons	84.1	84.6	93.5	84.8	93.1	74.2	46.0	46.5
	Percentage of irrigated lands use in Kysyl-Orda oblast	88.1	89.2	95.2	92.7	89.1	80.9	49.8	53.1

Percentage of irrigated lands use in mentioned rayons is negligibly less compared with average over oblast.

Intensive growth of irrigated lands area started since 1965 in Kazalinsk rayon. In 1965-1985 irrigated lands increase amounted for 1.2 th.ha. In 1985-2001 growth rate decreased all over the oblast. Since 1985 irrigated area reduced by 1.8 times.

Table 2.1.1.2
Irrigated lands change compared with 1990, %

Zone	1990 (maximum irrigated lands)-2001
Aral rayon	38.71
Kazalinsk rayon	96.23
Kazakh Prearalie	91.49
Kyzyl-Orda oblast	97.10

From figure it can be seen that area reduction was the same in Kazalinsk rayon and oblast as a whole, in Aral rayon reduction was sharp.

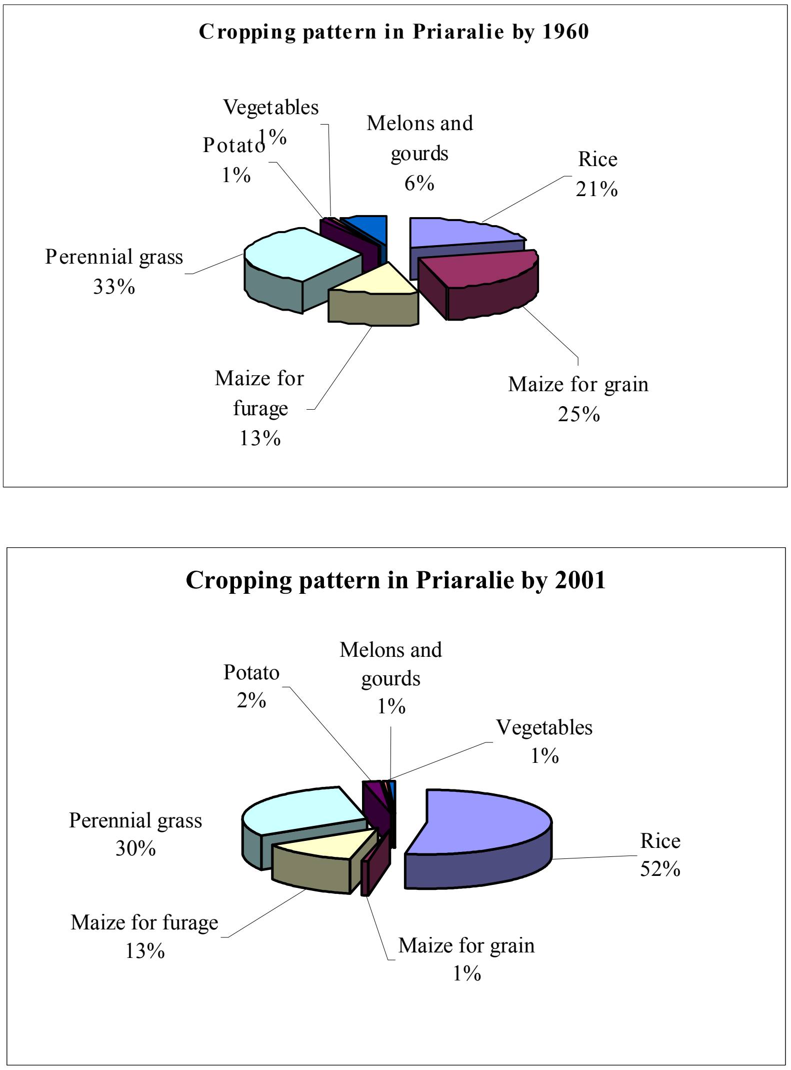


Fig.2.1.2

Since 1980 till 2001 in Kazalinsk rayon 14.2 th.ha were retired.

Recent years crop pattern also changed: grain - 8,5 th.ha, forage crops - 7,6 th.ha and vegetables-melons – 0,6 th.ha. Main grain crop is rice (21% in 1960; 52% in 2001), which is grown alternatively with dry crops on big areas (2-5 ha).

Analysis of 40-year data on rice yield and gross production shows that in last years rice production reduced dramatically. If in 1980 mean yield on Kazalinsk irrigation massif was 50,7 c/ha, in 2001 it was 22,7 c/ha.

Average yield over republic is negligibly higher compared with Kazalinsk rayon (in Aral rayon rice was grown only on 0,3 th.ha in 2001 with yield of 18,3 c/ha).

Rice gross production reduced by 2,8 times at expense of irrigated lands and its yield decrease. In 1980 rice gross production was 54,6 th.t, in 2001 - 19,7 th.t.

Gross production decrease in Kyzyl-Orda oblast started since 1985, in Prearalie – since 1980.

By 1990 sharp decline of all crops yield began on Kazalinsk massif. Since 1995 till 1998 this decline was: for rice – 42%, alfalfa and wheat – 46%, potato – 35%, vegetables – 43%.

Most vulnerable crops were: rice, maize for grain, perennial grass, vegetables and melons.

Table 2.1.3.
Comparison of main crops yield for Kyzyl-Orda oblast and Prearalie, cn/ha

Zone	Crops				
	Maize for grain	Rice	Perennial grass	Vegetables	Melons
Kyzyl-Orda oblast					
1980	13,1	49,0	57,0	54,0	180,2
2001	18,6	30,5	52,1	86,2	105,3
decline (times)	нет	1,6	1,1	нет	1,7
Aral rayon					
1996	6,9	21,0	34,2	-	120,1
2001	4,7	18,3	33,9	-	65,4
decline (times)	1,5	1,1	1,1	-	1,8
Kazalinsk rayon					
1980	7,5	50,7	54,2	43,7	161,3
2001	7,6	22,7	35,4	32,1	72,1
decline (times)	нет	2,2	1,5	1,4	2,2

Analysis showed that Prearalie is self-sufficient in potato on 80% and vegetables on 59,0%.

Analysis of yield since 1960 shows that trend of decline is observed starting from 1980. Mostly yield reduced in Kazalinsk rayon.

Nevertheless, crop production decline is explained by general economic trends but not by the Aral Sea desiccation.

2.1.2.Pastures and hay fields

Vast territories of Aral and Kazalinsk rayons are historically used as pastures for sheep, goats, camels, horses and cattle. White, saxaul, tarragon, keireuk, erkek pastures on brown, gray-brown loamy sandy loam and solonetz serve as natural forage base in spring-summer-fall period; erkek, tarragon pastures on sands are used mostly in spring and winter; sarsazan and Russian thistle pastures on solontchaks – in fall and winter.

Main hay fields in Prearalie are presented by reed, large-grained, tuber-reed and large-grained grass communities. Hay fields degradation began after 1974 when water discharge by Kazalinsk reduced by 10 times compared with 1960.
Ecological conditions change caused by ground water table lowering led to sharp hay fields degradation. Since 1960 till 1985 their area reduced by more than 7 times (from 59, 1 th.ha to 8,4 th.ha); in Kazalinsk rayon – more than 3 times (from 92, 3 th.ha to 29,4 th.ha).

Water release increase after 1989 facilitated hay yield increase but pastures area remained unchanged..

In 1960 hay field yield was 12,8 c/ha or 5,1 c/ha fodder unit with total stock 772,1 th.cn. f.u.; by 1990-1991 it reduced down to 3,2 c./ha (1.2 c/ha f.u.).

Reed fields were subjected to biggest transformation: in 1960 their area was 39.9 th.ha or 62% of all hay fields in Aral rayon and 43,5 th.ha (47%) in Kazalinsk rayon. By 1990 its area reduced by 14 times in Aral rayon and by 4 times in Kazalinsk rayon. Its yield capacity reduced by 3.5 times from 19,6 c/ha (7,4 c/ha f.u.) to 5,6 c/ha (1,9cn/ha f.u.).

In 2001forage losses were 171,4 th.t (68,7 th.t f.u.) compared with 1960 including reed losses 149,6 th.t (56,6 th.t f.u.).

Syrdarya delta hydrological regime change influenced hay fields: by 1985-1991 their area reduced by5 times and yield capacity – by 4 times. Semi-hydromorphous ecosystems were at verge of disappearance by 1990. Water release increase and anthropogenic load increase led to some stabilization but salinization process hinders their rehabilitation.

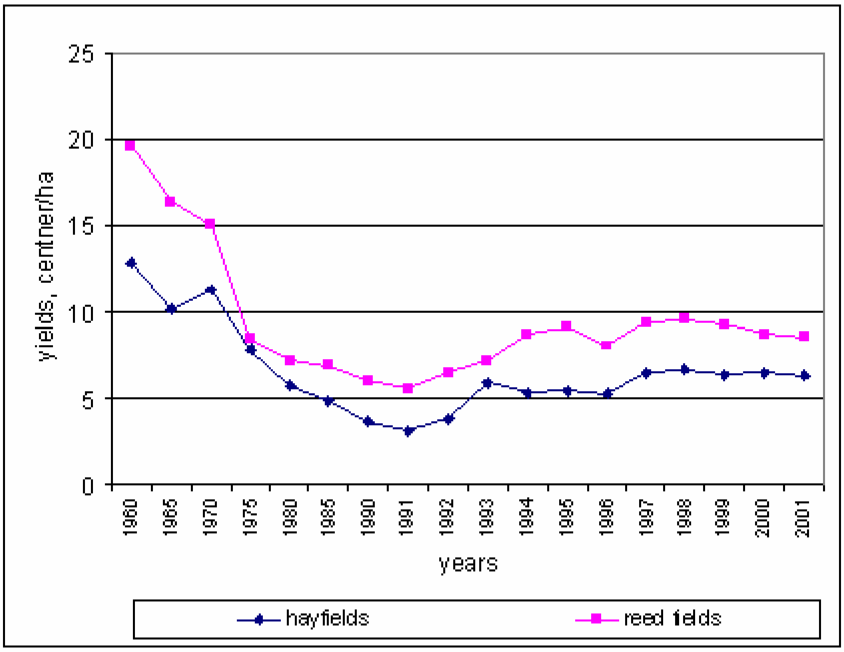


Fig.2.1.2.1. Hay fields yield capacity in Kazakh Prearalie

Table 2.1.2.1
Dynamics of agricultural lands structure changes in Kazakh Prearalie, th. ha

Zone	Name	1960	1970	1975	1980	1990	1995	2001
Aral rayon	Irrigated lands	0.3	0.4	0.4	0.4	0.5	0.3	0.7
	Hay fields	59.1	49.1	48.4	40.6	8.4	9.5	6.3
	Fallow lands	2.1	0.1	0.1	0.3	2.9	2.1	2.7
	Pastures	1336.2	1783.1	1994.3	1977.3	1877.4	2154.9	2210.4
	Total	1397.7	1832.7	2043.2	2018.6	1889.2	2166.8	2220.1
Kazalinsk rayon	Irrigated lands	2.8	14.3	18.8	30.2	32.1	27	16
	Hay fields	92.3	78.7	77.3	34.7	28.9	27.5	27.6
	Fallow lands	3.7	16	10.8	8	4.1	1.7	18.9
	Pastures	2735.7	2760	2823.6	2817.3	1542.7	1433.4	1599.7
	Total	2834.5	2869	2930.5	2890.2	1607.8	1489.6	1662.2
Kyzylorda oblast	Irrigated lands	56.8	124.2	169.4	217.3	244.8	214.1	124
	Hay fields	386.2	376.1	332.8	130.1	106.8	114.1	115.2
	Fallow lands	23	1	40.1	28.9	35	54.8	129.8
	Pastures	12239.6	15664.5	15786.2	13633.2	11290.6	10999.2	11868.2
	Total	12705.6	16165.8	16328.5	14009.5	11677.2	11382.2	12237.2

Table 2.1.2.2
Dynamics of agricultural lands structure changes, (+/-) times

Zone	Name	1960-2001	1970-2001	1980-2001	1990-2001
Aral rayon	Irrigated lands	2.3	1.8	1.8	1.4
	Hay fields	-9.4	-7.8	-6.4	-1.3
	Fallow lands	1.3	27.0	9.0	-1.1
	Pastures	1.7	1.2	1.1	1.2
	Total	1.6	1.2	1.1	1.2
Kazalinsk rayon	Irrigated lands	5.7	1.1	-1.9	-2.0
	Hay fields	-3.3	-2.9	-1.3	-1.0
	Fallow lands	5.1	1.2	2.4	4.6
	Pastures	-1.71	-1.73	-1.8	1.04
	Total	-1.71	-1.73	-1.7	1.03
Kyzyl-Orda oblast	Irrigated lands	2.2	1.0	-1.8	-2.0
	Hay fields	-3.4	-3.3	-1.1	1.1
	Fallow lands	5.6	129.8	22.3	3.7
	Pastures	-1.03	-1.32	-1.1	1.05
	Total	-1.04	-1.32	-1.1	1.05

From table it can be seen that trends of agricultural lands improvement were observed compared with 1990.

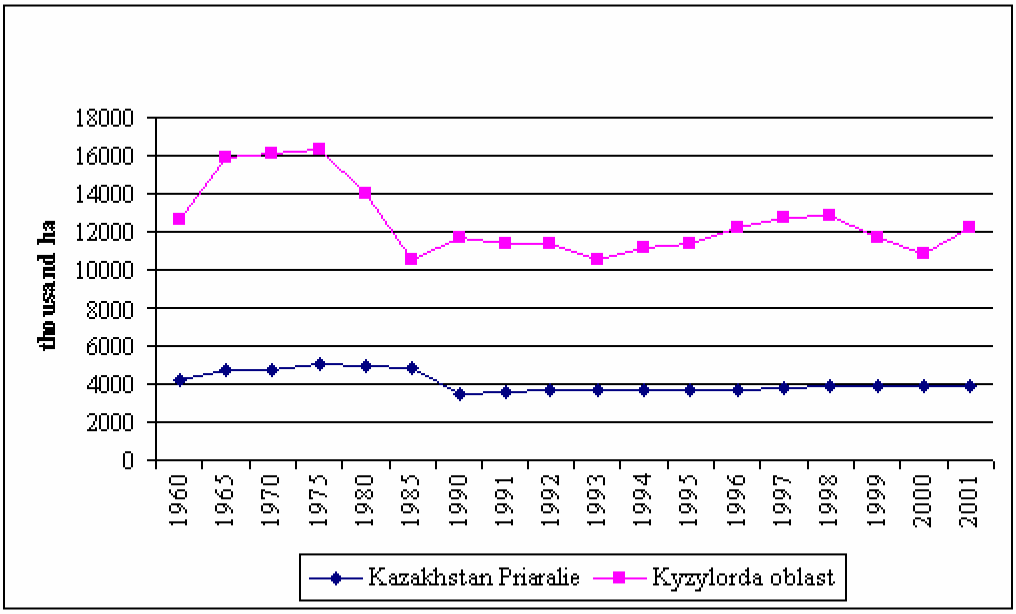


Fig. 1.2.2. Agricultural lands dynamics

Graph shows that agricultural lands area reduction process started since 1975 in oblast and since 1985 in Prearalie.

2.1.3. Meat farming

In Kazakh Prearalie livestock is the second agricultural sector (40%). Main product is beef. Meat farming is profitable only for farms, which have hay fields.

During recent 10 years livestock is characterized by its population and productivity decline. Under agricultural reforming most livestock population was transferred to small peasant farms and farmers.

Table 2.1.3.1.
Livestock population, th. t

Zone	Indicators	1960	1970	1980	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aral rayon	Cattle	12.1	19.8	17.3	18.8	23.7	23.4	19.4	16.8	19.3	19.5	20.2	21.2	21.2
	Sheep and goats	72.1	166.3	150	152.3	163.8	166.5	131.7	98.6	93.2	85.6	83.5	90.4	90.3
	Horses	13.9	14.5	16.1	10.1	15.5	15.8	13.7	11.9	11.7	11.8	11.5	11.7	11.5
	Camels	9.8	11.9	12.6	8.2	11.6	11.7	12.1	11.2	12.9	13.1	13.1	13.3	13.2
	Total	107.9	212.5	196	189.4	214.6	217.4	176.9	138.5	137.1	130	128.3	136.6	136.2
Kazalinsk rayon	Cattle	24.5	34	28.3	31.4	35.9	35.7	28.1	24.5	22.5	22.5	23.5	23.8	23.6
	Sheep and goats	196.5	274.2	296.2	290.4	284.7	249.8	159.7	118.2	71.2	71.1	71.4	71.5	71.2
	Horses	12.5	11.8	15.4	12.4	12.9	13.2	9.2	8.3	6.8	6.7	6.8	6.3	6.2
	Camels	3.1	4.5	4.6	4	4.5	4.5	3.7	3.2	2.6	2	1.6	1.8	1.8
	Total	236.6	324.5	344.5	338.2	338	303.2	200.7	154.2	103.1	102.3	103.3	103.4	102.8
Kyzyl-Orda oblast	Cattle	169.5	188.7	182.8	220.8	235.1	186.5	166.1	163.7	151.7	152.6	157.9	159.9	159.8
	Sheep and goats	1537.1	1486.5	1368	1596.6	1610.6	1549.6	979.1	820.1	547.8	505.9	537.8	540.3	540.2
	Horses	46.2	47.4	51.4	71.9	77.2	77.6	64.9	58.3	48.5	47.1	48.7	46.4	46.3
	Camels	23.4	22.2	19.3	26.4	27.7	27.8	25.8	23.6	20.5	19.3	18.7	19	18.9
	Total	1776.2	1744.8	1621.5	1915.7	1950.6	1841.5	1235.9	1065.7	768.5	724.9	763.1	765.6	765.2

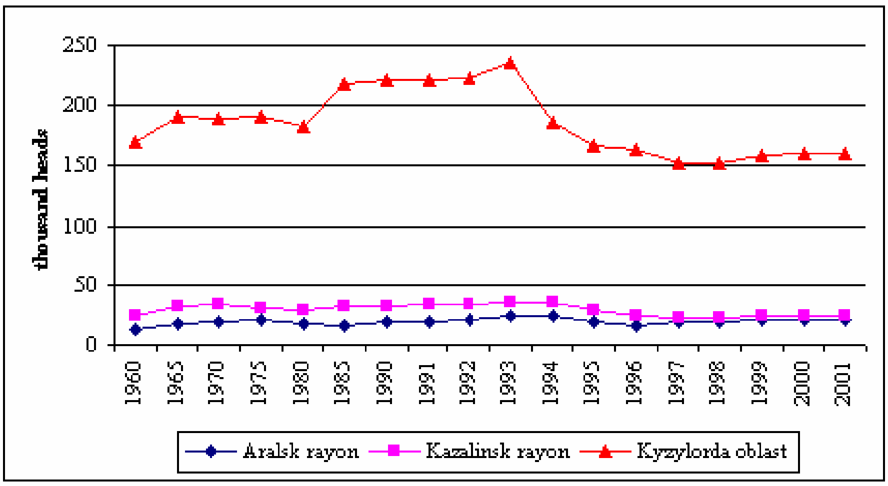


Fig. 2.1.3.1. Cattle population

All-republican trends are almost the same.

Table 2.1.3.2
Meat production (live weight), th. t

Zone	1960	1965	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aral rayon	3.9	3.7	3.2	3.2	3.5	3.3	3.4	3.1	3	2.8	2.7	2.9	1.8	2	2	2	2.5	2.4
Kazalinsk rayon	3.8	4.6	4.8	5	5.2	6.2	4.1	3.5	3.8	3.8	3.4	4.4	3.5	3.8	3.6	4	4.1	4.1
Kyzyl-Orda oblast	30.1	38.2	42.5	46.8	54.1	52.4	58.8	51.2	59.3	44.4	39.5	26.9	27.6	28.4	25.5	25.9	25.4	25.2

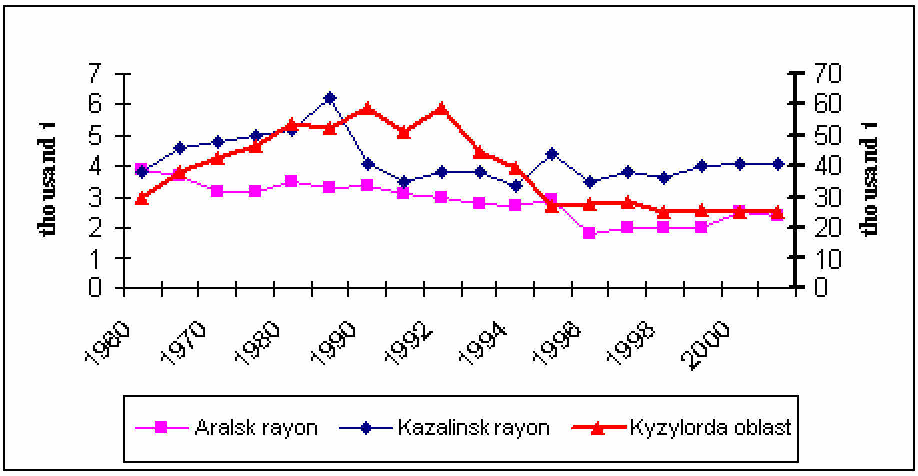


Fig. 2.1.3.2. Meat production

Meat production decline in Prearalie is observed after 1985, in oblast – after 1992.

Livestock productivity declined after 1985. Compared with 1985 milking capacity reduced by 1,2 times from 1086 kg to 854 kg; since 1994 till 1998 milking capacity was 951 kg. Since 1985 general trend of milking capacity decline in Prearalie is observed (from 1086 to 892 kg) as well as in oblast as a whole (from 2014 to 887 kg).

Table 2.1.3.3
Milk production, th. t

Zone	1960	1965	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aral rayon	1.1	1.3	2.5	3.8	3.8	3	1.9	2.8	2.7	3.7	3	3	3	4.5	4.6	4.6	4.6	4.5
Kazalinsk rayon	5.8	6.6	7.1	7.5	8.1	8.5	3.1	3.9	4.1	4.9	6	7.7	5.4	5.6	5.5	6	6	5.6
Kyzyl-Orda oblast	32	32.3	48.8	51.5	56.7	66.9	102.1	103.9	100.6	117.2	83.1	54.7	44.8	45.3	64.4	61.4	54.6	51

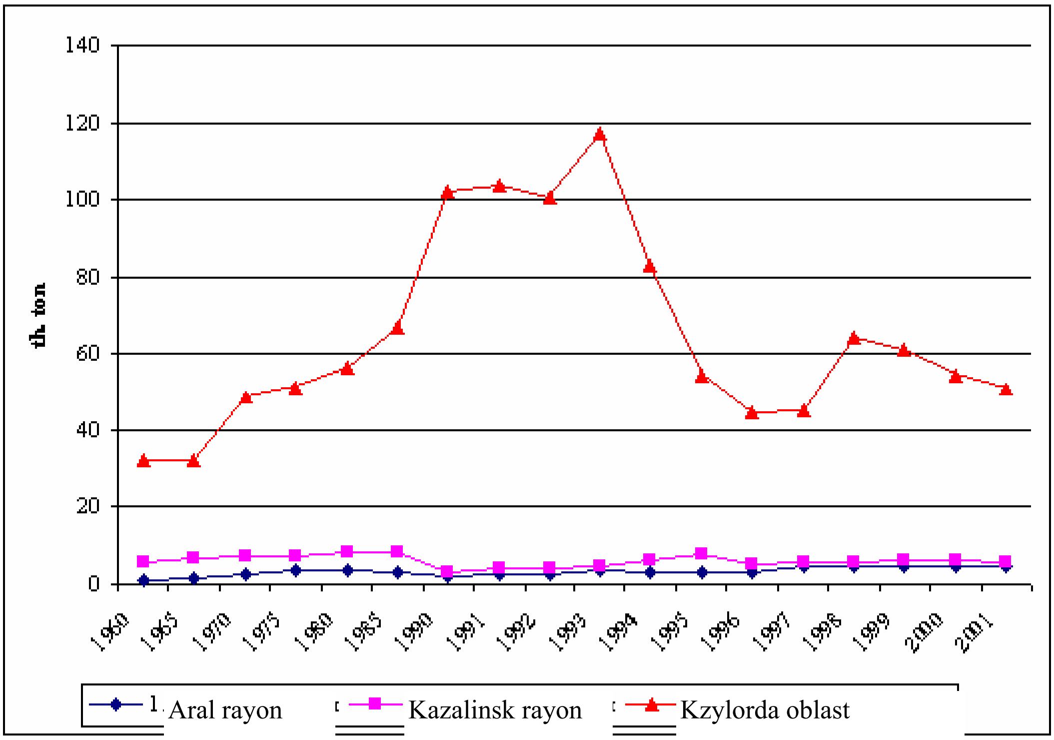


Fig. 2.1.3.3. Milk production

Along with sheep and cattle breeding, horse and camel breeding is developing. All karakul farms of Aral and Kazalinsk rayon were profitable before 1985.

Profitable degree in some farms reached 60%. Main income farms received from live-stock production: sheepskin (32,0-39,7%), wool (36,2-40,6%) and mutton (24,1-27,4%). In time being sheep breeding is unprofitable.

Table 2.1.3.4
Production of karakul sheepskin (according to agricultural department), th. pieces

Zone	1960	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aral rayon	28.4	80.9	82.4	102.1	98.6	98.7	74.8	81.2	36.2	33.1	24.5	16.4	10.1	7.2	0	2.3	1.4
Kazalinsk rayon	62.4	102.5	129.9	168.1	112.1	82.4	89.5	96.8	50.6	42.7	32.8	24.7	13.4	12.7	6.2	10.1	8.7
Kyzyl-Ordaoblast	198.6	452.8	492.5	616.8	591.1	562.4	425.2	488.2	413.5	465.1	235.9	221.7	186.1	150.2	136.4	102.3	98.1

Karakul production suffered much. Since 1985 sheepskin production reduced by 20 times. Min losses took place after 1990-1993 when sheep and goats population was sharply declined and pastures productivity reduced. Main losses were in karakul sheepskin.

Table 2.1.3.5
Wool production, th. t

Zone	1960	1965	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aral rayon	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.3	0.1	0.2	0.1	0.1	0.2	0.1	0.2	0.2
Kazalinsk rayon	0.09	0.1	0.2	0.2	0.3	0.3	0.5	0.3	0.3	0.4	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.1
Kyzyl-Ordaoblast	1.8	2	2.2	2.4	2.8	3.7	2.2	2.1	1.9	2	0.8	1.7	1	1.1	0.8	0.8	0.8	0.8

Forage base state is reflected in daily weight increment. Since 1980 till 2001 average daily weight increment reduced by 1,4 times from 202 g to 150 g, sheep - by 1,2 times from 87 g to 69 g.

Livestock population and its productivity decline negatively impacted livestock as a whole, which is now unprofitable. Fodders cost (50% of total production cost) increased by 5 times, milk production cost – by 6 times, wool production – by 10 times, daily weight increment – by 11 times.

Sector indicators analysis shows that livestock productivity decline began since 1985; decline rate is higher in Kazalinsk rayon compared with Aral rayon. This proves that main reason for decline is social-economic situation aggravation.

Table 2.1.3.6
Livestock productivity, average daily weight increment, g

Zone	Items	1960	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aral rayon	Cattle	205	204	197	202	186	174	165	154	148	150	152	147	146	142	147	145	150
	Sheep and goats	102	96	89	87	85	78	75	72	68	65	67	64	68	65	68	67	69
	Wool, kg	3.1	2.9	2.8	2.6	2.5	2.1	2	1.3	1.9	0.7	1	1	2.1	2.3	2.2	2.1	2.1
	Sheep skins, pieces	0.57	0.56	0.56	0.55	0.55	0.48	0.47	0.42	0.38	0.38	0.37	0.32	0.34	0.34	0.32	0.33	0.34
Kazalinsk rayon	Cattle	207	211	204	208	194	179	164	157	152	154	156	150	154	148	152	147	153
	Sheep and goats	100	89	87	92	87	76	77	74	73	74	75	73	69	70	74	72	76
	Wool, kg	3.2	2.7	2.6	2.6	2.5	1.8	1.5	1.6	1.7	1	1	1	2.1	2.2	2.1	2.1	2.1
	Sheep skins, pieces	0.56	0.55	0.54	0.54	0.53	0.46	0.45	0.38	0.36	0.37	0.34	0.32	0.34	0.32	0.36	0.35	0.33
Kyzyl-Orda oblast	Cattle	246	230	215	214	198	182	177	169	169	172	175	181	179	183	180	175	177
	Sheep and goats	105	98	94	96	89	81	78	78	82	80	79	81	76	79	82	75	73
	Wool, kg	3.2	2.8	2.6	2.6	2.6	1.6	1.5	1.5	1.6	0.7	1.3	1.1	2.6	3.1	2.6	2.4	2.1
	Sheep skins, pieces	0.58	0.56	0.56	0.55	0.55	0.54	0.51	0.5	0.49	0.47	0.51	0.5	0.49	0.52	0.5	0.48	0.47

2.1.4. Fish breeding

Syrdarya and Amudarya flow regulation and water diversion for irrigated agriculture led to the Aral Sea desiccation. Fish production it totally declined.

Table 2.1.4.1.
Dynamics of fish production in Kazakh Prearalie* (th. t)

Years	Total	including		Years	Total	including	
		In Northern sea	In lake systems			In Northern sea	In lake systems
1960	21,2	16,1	4,7	1980	2,9	-	2,9
1961	20,7	16,2	4,5	1981	3,3	-	3,3
1962	20,4	17,0	3,4	1982	3,1	-	3,1
1963	22,0	16,5	5,5	1983	3,0	-	3,0
1964	21,3	15,8	5,5	1984	3,2	-	3,2
1965	14,9	12,9	2,0	1985	3,1	-	3,1
1966	10,3	8,1	2,2	1986	2,9	-	2,9
1967	9,5	7,7	1,7	1987	3,2	-	3,2
1968	9,6	7,1	2,5	1989	3,4	-	3,4
1969	9,4	7,0	2,4	1990	2,8	-	2,8
1970	10,4	7,5	2,9	1991	3,6	0,05	3,55
1971	10,8	8,9	1,9	1992	2,5	0,1	2,4
1972	11,5	9,2	2,3	1993	2,1	0,05	2,05
1973	9,1	7,0	2,1	1995	1,5	0,008	1,492
1974	9,5	7,2	2,3	1996	0,5	-	0,5
1975	7,3	6,3	1,0	1997	0,7	0,1	0,6
1976	4,5	3,4	1,1	1998	0,4	0,05	0,35
1977	2,3	0,9	1,4	1999	0,2	0,03	0,17
1978	2,26	0,06	2,2	2000	0,3	0,06	0,24
1979	2,5	-	2.5	2001	0,2	0,03	0,17

* According to Fish Breeding Ministry.

From table it can be seen that fish production in Northern sea reached maximum values in 1963 (17 th.t/yr), in lake systems in Syrdarya delta - near 5,5 th.t/yr.

Since 1966 till 1972 fish production decline was observed (in Northern sea to 7 th.t/yr). Then new decline began in 1976 and since 1979 production was ceased. Fish production has been renewed since 1997 when Black sea flat-fish population became highest but its production does not exceed 200-300 t/yr.

There were 20 fish species in Northern sea in 1938, 30 species in 1954-1980 and only 9 species in 1994 including 8 acclimatized species. From indigenous species only Aral kolyushka remains until now.

Table 2.1.4.2
Dynamics of fish production in Northern sea and lake systems (th. t)*

Years	Vobla	Sandre	Sazan	She-afish	Bream	Pike	She-lesper	She-maya	Bar-bel	Large chastik	Small chastik	Total
1960	38,1	6,7	65,1	5,5	34,8	20,2	4,9	6,1	2,5	-	28,6	212,5
1961	36,6	10,6	67,3	7,0	30,0	20,0	7,0	2,6	2,1	-	24,2	207,4
1962	29,6	12,1	84,0	5,5	26,2	10,9	8,5	4,8	2,6	-	19,6	203,8
1963	32,6	23,7	93,8	4,1	24,7	6,4	10,4	3,2	2,6	-	18,6	220,1
1964	26,9	27,5	86,4	2,4	22,5	11,7	12,6	2,8	1,9	-	18,4	213,1
1965	25,6	15,0	49,9	2,6	11,6	12,1	12,6	1,4	0,8	-	18,0	149,6
1966	18,1	8,5	30,1	2,2	10,4	5,7	10,5	1,8	0,5	-	15,8	103,6
1967	18,6	14,3	18,4	1,3	8,6	5,8	15,5	0,8	0,3	-	11,8	95,4
1968	21,4	19,5	17,5	0,8	9,1	2,4	20,6	0,8	0,6	-	3,5	96,2
1969	24,3	19,4	15,3	0,7	7,1	6,8	16,6	0,2	0,4	0,4	3,0	94,2
1970	32,2	8,9	14,6	0,7	12,2	17,1	12,2	0,3	0,1	0,6	5,1	104
1971	30,3	35,9	9,6	1,0	9,3	6,8	9,5	0,1	0,1	1,9	3,6	108,1
1972	18,8	56,7	11,4	1,0	6,7	4,7	6,0	0,0	0,1	1,7	7,8	114,9
1973	12,5	32,7	8,6	0,8	7,7	5,9	15,9	0,0	0,0	2,1	5,0	91,2
1974	16,8	21,0	6,7	0,7	8,8	6,8	26,0	0,0	0,1	1,7	6,3	94,9
1975	16,7	17,7	7,0	0,5	10,1	4,9	6,9	0,1	0,2	1,8	7,3	73,2
1976	14,4	14,9	1,4	0,1	5,8	1,4	1,7	0,0	0,1	1,5	3,3	44,6
1977	5,8	6,9	1,7	0,2	2,6	0,6	1,0	-	0,0	1,6	2,5	22,9
1978	2,5	1,1	1,8	0,4	15,8	0,3	0,1	-	-	0,3	2,8	25,1

* According to Fish-breeding Ministry and «Aralribprom» association.

In Syrdarya downstream stable fish production (2 th.t/yr) were fixed before 1995, then it declined to 0,03 th.t/yr in 2001. Irregular flooded zone inundation and some lake systems disappearance were major reasons for this decline.

Nowadays, only two lake systems (Kamislibas and Akshatau, partially – Aksai-Kuadarya) are in operation. But fish population on these systems sharply declined except fish-predators.

Fish production in Syrdarya downstream lakes began reduce after Shardara dam construction.

In 1976 fish-breeding farm has been established on Kamislibas lake. Because of this fish production reached 23 th.c in 1985 that is more than in 1970. But this farm has been privatized and then ceased its activity. All fish production plants were closed.

Table 2.1.4.3
Dynamics of fish production in Syrdarya downstream lakes, th. cn*

	Kamishlibash	Akshatau	Aksi-Akerek	Aksai-Kuvandarya	Total
Before river regulation					
1960	8,0	2,8	12,8	23,4	47,0
1961	7,6	13,0	6,8	18,4	45,8
1962	6,1	3,2	13,6	16,1	39,0
1963	3,8	5,0	28,2	18,0	55,0
1964	12,8	7,5	14,2	16,8	51,3
After river regulation					
1965	7,4	0,5	1,8	11,2	20,9
1970	12,0	8,8	2,5	6,5	29,8
1975	3,3	5,3	-	2,1	10,7
1980	22,2	5,0	-	1,9	29,1
1985	23,5	6,4	-	1,5	31,4
1990	20,3	7,1	-	1,0	28,4
1995	10,4	4,1	-	0,5	15,1
2000	1,4	1,0	-	-	2,4

* According to Kazalinsk rayon fish department

2.1.5. Mask rat breeding

In 1948 mask rat acclimatization began. More than 120 fishes were put in Syrdarya. Mask rat skins production was launched since 1951 and reached maximum production in 1965 when 68 th. skins were produced. But by 1976 due to wetlands drying up mask rat production was finished.

Table 2.1.5.1.
Mask rat skin production in Kazakh Prearalie (pieces)

Years	1951	1960	1965	1970	1975
Skins	1012	38452	68012	36014	945

Low labor productivity, high production losses led to sharp growth of skin production cost in 1970: from 97kopeks per skin in 1965 to 5 rubles 84 kopeks in 1975.

Due to the Aral Sea desiccation and water supply to delta cessation mask rats completely perished

2.1.6. Aral Sea and Prearalie recreation significance losses

Aral Sea coastal zone was place of rest for local population where annually 2 thousand people had rest. Since 1982 special recreation zone functioned: pioneer camp, camping, good beeches have been built.

In result of the sea desiccation since 1976 pioneer camp on 200 places was closed. On Kamislibas lake in 1978-1982 there was pioneer camp on 150 places for military men children.

In Aralsk biological complex has been built on base of thermal source for 500 people annually. Since 1986 further treatment became impossible.

Presently, twp pioneer camps function in Prearalie: "Chaika" (Kazalinsk rayon) on Syrdarya shore since 1972 (150 children) and camp on Kamishlibash lake (Aral rayon) (100 children) since 1986.

Kamislibas Lake is a tourist place. In 1970-1985 it was visited annually by 3 thousands people during 5 days on average. Presently, this number reduced to 1 thousand.

2.1.7. Fish processing losses

Aral Sea gave about 7% of fish production from internal water bodies in USSR. Fish production decline during 1960-1980 caused «Aralribprom» losses in amount of 155,6 mln. rubles including Northern Aral - 130 mln. rubles. It is necessary to take into account "Aralribprom" main assets, which were out of operation (mooring, warehouses, refrigerators, fleet) (5 mln. ruble from total cost 13 mln. ruble). Total losses in fish production industry amounted for 140 mln.rubles.

2.1.8. Skin processing losses

Presently, wool and skin production sharply declined. Analysis shows that since 1985 this production reduced by 20 times (see section 2.2.3.). Main losses started in 1991-1993 and caused by sharp decline in sheep and goats population.

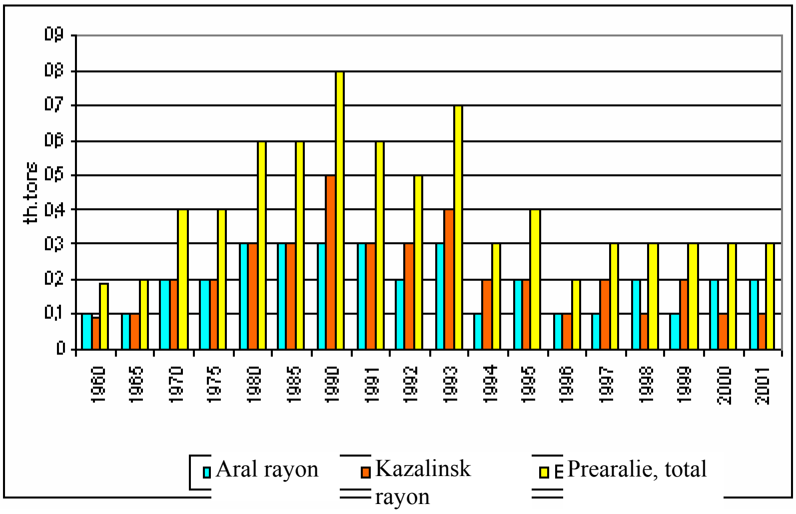


Fig.2.1.8.1. Wool production

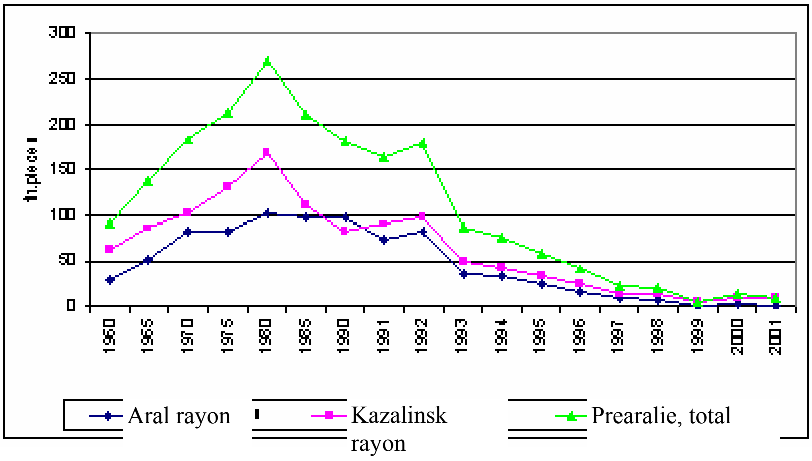


Fig.2.1.8.2. Karakul skins production

In result of wool and skin production cost increase all livestock profitability reduces.

2.1.9. Reed processing decline

Reed is widely used in construction, paper production and chemical industry.

Reed brushwood on meadow-swamp, turf-swamp and swamp soils had production significance. Reed height reached 3-4m and dry mass yield varied within 10-15 t/ha.

In 1958 in Kyzyl-Orda cartoon plant construction has been started based on local row material. According to L.F.Demidovskaya, annual demand for reed was 140 th.t.

Main source of row material were Karauzyak and Koksu massifs near Kyzyl-Orda city. In Aral and Kazalinsk rayon reed brushwood was not very important.

According to Institute of Botanic, in 1959-1963 total reed supplies amounted for 87,54 th.t (32,4 th.t. f.u.).

By 1978, according to S.A.Yerembetov, in Aral and Kazalinsk rayon reed brushwood fully lost their productive significance. Projective cover reduced down to 50%, reed height did not exceed 0,2-1m. Due to lack of row material in the end of 70-es Kyzyl-Odra plant has been reconstructed for timber.

In 1960 in Kazakh Prearalie reed supplies amounted for 163,5 th.t (under forage yield capacity 19,6 t/ha), by 2001 they reduced to 13,9 th.t.

2.1.10. Maritime transport decline

Maritime transport was one of leading economic sectors in Kazakh Prearalie. Navigation was started in 1909 when because of Orenburg-Tashkent railway construction (1905) necessity appeared to transport agricultural production from oases of Syrdarya and Amudarya lower reaches to central regions of Russia.

In 1960-es two regular lines existed on the Aral Sea: Aralsk-Muinak and Aralsk-Taldik port (Amudarya mouth) providing inter-region transportation in Prearalie.

With Chardzhou-Kungrad-Makat-Alexandrov Gai railway completion (1960-1970), maritime transportation was sharply reduced. Nevertheless, it covered 1/3 of inter-region and 1/5 of in-region transportation in the end of 70-es.

Initial Aral Sea fall led to Big Sarishiganak (where port Aralsk located) bay shoaling that negatively effected transportation. Necessity appeared in port reconstruction and in 1979 port has been closed because of high financial losses.

Maritime transportation in 1978 reduced by 2 times compared with 1960 and load processing – by 4 times.

Ship repairing plant until 1985 was used for river ships building for Siberia and Far East transported by railway. Presently, there is railway workshop instead of this plant.

2.2. Social losses

2.2.1 Level of socio-economic development

Level of socio-economic development of Kazakhstan Prearalie is characterized by very low production and consumption of material goods. Regional Gross Product amount in 2000 was 2.4% in structure of republican Gross Domestic Product (GDP) and appeared the lowest among all oblasts of Kazakhstan. GDP of Kyzylorda oblast in 2000 was 56450,5 mln. tenge, having increased 2.7 times against 1995.

Table 2.2.1.1
Basic socio-economic indicators of Kyzylorda oblast

Indicators	1995	1996	1997	1998	1999	2000
Population number, th. people.	605,9	605,4	609,2	614,9	596,2	601,2
Natural increment, th. people per 1000	 11006 16,3	 9298 15,3	 8758 14,4	 8872 14,3	 8309 14,0	 8156 13,3
Average annual number of people engaged in economy, th. people.	234,2	252,2	239,4	243,2	264,1	250,9
Total number of jobless, th. people.	7,5	12,7	11,9	36,6	41,0	37,2
Financial incomes (on average per capita per month), tenge $ USA	777,8 20,4	1128,1 37,8	3425 45,4	3653 43,5	3687 26,7	4087 28,3
Financial costs (on average per capita per month), tenge $ USA	314,1 17,7	479,6 32,9	3382,9 44,8	3690,2 44,0	3667,4 26,5	3993,8 27,6
Average monthly wages per 1 worker, tenge $ USA	 3992,9 65,81	 7669,1 113,99	 8881,3 117,55	 10071 120,08	 10310 74,61	 11786 81,56
Gross Domestic Product (GDP), total, mln. tenge per capita, th. tenge per capita, $ USA	 21211,5 36,0 520,3	 32947,4 56,0 649,4	 38578,8 65,3 864,3	 33542,4 56,5 673,7	 35215,9 58,8 425,5	 56450,5 93,6 632,2
Industrial output, bln. tenge mln. $ USA	7,7 126,9	12,4 184,9	16,9 224,2	17.2 204,6	26,3 190,8	63,4 438,9
Agricultural output, bln. tenge mln. $ USA	3,7 60,4	7,5 111,8	5,8 76,5	6,4 76,2	6,7 48,6	8,6 59,4

Gross value added per capita in Kyzylorda oblast in 2000 was 93.6 th. tenge against 156.6 th.tenge over Kazakhstan. In hard currency equivalent regional Gross Product per capita in Kyzylorda oblast from 1985 to 2000 reduced from $3223.68 to $647.75 almost 5 times, though in national currency its growth is noted.

Industrial production increased from1995 to 2000 almost 8 times at the expense of development in region of oil mining industry, and agricultural production grew more than twice. Average provincial number of people dealing with economy increased for five year period from 234,2 to 250,9 th. people, and in Aralsk and Kazalinsk rayons reduction of economically active population occurs that is connected with outflow of able-bodied population from ecologically unfavorable region.

Indices of basic social-economic indicators, characterizing results of development of Kazakhstan and Kyzylorda oblast for 2000 (in% by 1999)

Table 2.2.1.2

	Amount of industrial output (works, services)	Investments in capital construction	Index of tariffs for cargo transportation by all types of transport	Index of consumable prices	Index of prices for agricultural output sale	Index of industrial producers	Nominal monthly wages
Kazakhstan	115,5	106,5	122,7	109,8	124,9	119,4	121,2
Kyzylorda oblast	132,7	103,3	100,0	109,7	121,1	185,0	111,5

2.2.2. Demographic situation deteriorating in Kazakhstan Prearalie

For period 1960-2001 demographic development of Kazakh Prearalie was characterized by common regularities and tendencies typical for the republic in general. Population number in Kyzylorda oblast increased from 344.8 th. to 605.5 th. people (almost twice) due to urban population growth.

Urban population for period 1960-2001 increased 2.1 times from 174.3 th. in 1960 to 365.4 th. people in 2001, while rural population number increased insignificantly from 170.4 th. to 240.1 th. people, appropriately.

On territory of Aralsk and Kazalinsk rayons about 23% of all population of Kyzylorda oblast is concentrated. As for population number, studied rayons are practically equal, but as for processes of population reproduction and growth rates, they are different.

On general background of predomination of rural population within 7 administrative rayons of Kyzylorda oblast in 2001 only in three ones – Aralsk, Kazalinsk, and Karmakshinsk predomination of urban population over rural one was registered. So, in Aralsk rayon specific weight of urban population was 63.0%, in Kazalinsk – 59.0%.

The highest rate of population number were noted in period 1965-1970 in Kyzylorda oblast (119%), in Aralsk (123.6%) and Kazalinsk (137.2%) rayons. In urban settlements growth rates in both rayons exceeded 142%, for studied period they were the highest indicators of population growth rates over oblast.

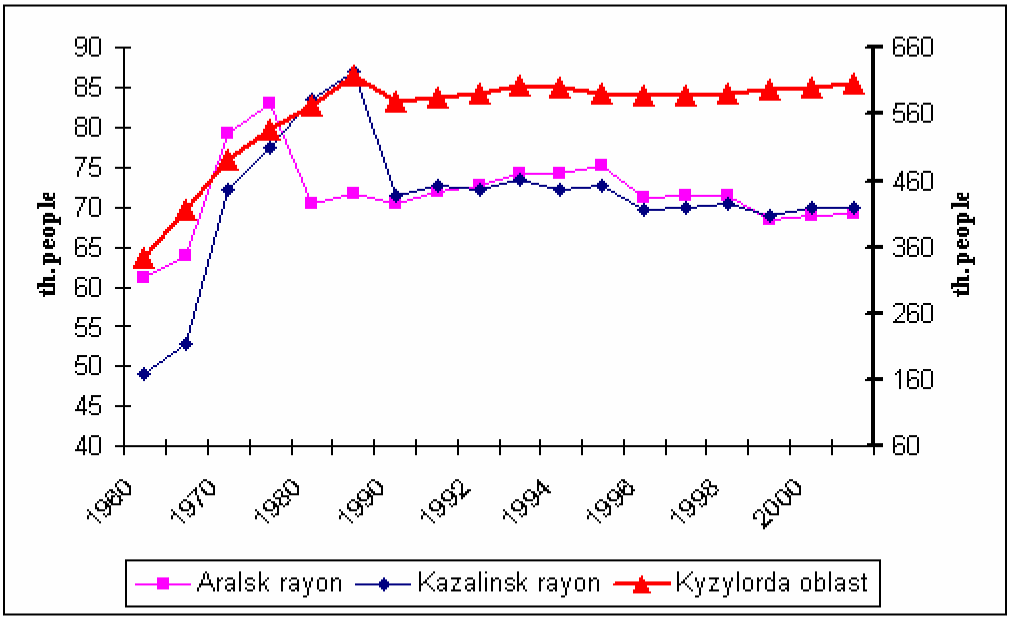


Fig. 2.2.1. Population number

Table 2.2.2.1
Indicators of population number growth rates in Kazakhstan Prearalie for period 1960-2001, %

	1965 by 1960	1970 by 1965	1975 by 1970	1980 by 1975	1985 by 1980	1990 by 1985	1991 by 1990	2000 by 1999	2001 by 2000
Aralsk rayon- total	**104,7**	**123,6**	**104,8**	**84,9**	**101,9**	**98,1**	**102,1**	**100,9**	**100,3**
Urban population	121,7	142,3	104,4	96	107,1	93	102,9	100,7	100
Rural population	89,4	99,7	105,6	83,2	92,5	109,5	100	101,6	100,8
Kazalinsk rayon - total	**107,8**	**137,2**	**107,2**	**107,8**	**104,3**	**82,1**	**101,7**	**101,6**	**100**
Urban population	112,4	143,2	110,4	108,4	105,3	70,7	102,3	100,5	100,7
Rural population	101,9	128,8	102,1	106,6	102,6	102,2	100,9	101,4	101,4
Kyzylorda oblast - total	**120,9**	**119,2**	**108,1**	**107,5**	**108**	**93,7**	**100,8**	**100,8**	**100,7**
Urban population	126,7	122,6	118,4	113,9	115,4	84,6	100,9	100,8	100,4
Rural population	115,2	112,7	95,7	97,7	95,7	111,9	100,4	101,1	101,1

* It was calculated on: Demographic yearbook of Kazakhstan, 2000 – Almaty., 2002. – P. 108.; Number and accommodation of population in Kazakhstan. Vol. 1. Results of census 1999 in Kazakhstan. Almaty. Agency of RK on statistics, 2000. – P. 8.

Period 1990-2001 can be characterized by the highest stability of population growth rates both in studied rayons and Kyzylorda oblast.

One conclusion can be made that basic source of population number growth in Kazakhstan Prearalie is high natural increment of population, which is redeemed at the expense of ecological refugees and population outflow from ecological disaster zone.

Analysis of indicators on gender and age structure of population determined on base of census data of 1959, 1970, 1979, 1989, 1999 years provides conclusion that the biggest specific weight in population structure in Kyzylorda oblast corresponds to persons of able-bodied age, herewith for studied period it increased by 9.6 points that shows availability of labor capacity in oblast.

Table 2.2.2.2
Specific weight of able-bodied population in Kyzylorda oblast in dynamics, %

Years	1959	1970	1979	1989	1999
All population	100	100	100	100	100
Younger than able-bodied	39	41,60	43,90	45,40	36,40
Able-bodied	47,50	49,70	48	46,40	57,10
Elder than able-bodied	13,50	8,70	8,10	8,20	6,50
Men	100	100	100	100	100
Younger than able-bodied	41,30	41,90	45,20	46,30	46,50
Able-bodied	48,50	51,10	46,70	48,70	48,70
Elder than able-bodied	10,20	7,00	8,10	5,00	5,40
Women	100	100	100	100	100
Younger than able-bodied	36,50	41,20	42,60	44,40	35,70
Able-bodied	46,50	48,30	46,30	44,30	56,70
Elder than able-bodied	17,50	10,50	11,10	11,30	7,6

* Calculated on census data of 1959, 1970, 1979, 1989, 1999 years.

In general for Kazakhstan Prearalie high "ability to be changed" of able-bodied generations that creates favorable conditions for labor resources availability for future.

2.2.3. Migration of population

One of the main factors effecting population number change is migration. For recent years social-economic and demographic indicators, defining character of migration flows, have changed radically.

Since 70-ties population outflow became more intensive from Kyzylorda oblast. As for migration mobility of population in period 1970-2001, Kyzylorda oblast yields majority of Kazakhstan oblasts. Of all republican amount of migration flows the share of this oblast was 2.4%. Especially arrival flows are weak here. Since 1970 migration balance in oblast is negative.

High population outflow from Kyzylorda oblast from 1970 to 1995 can be explained by such factors as deterioration of ecological state of Aral region that resulted in emergence of new kind of migrants – ecological, and that was proved by attempts of Government, who failed to relocate part of population from ecological disaster zone to Kokchetav oblast; loss of job places and search of new job in other rayons or outside oblast that was related to Aral Sea level decline and closing of fishery and fishing, where in period of high reservoir productivity significant part of population dealt with fishing and branches related to processing of fish product, repair of fishing ships, etc.

In 2000 migration balance was minus 3646 people. Number of people leaving oblast was 6365, and arriving number 3734 (37% of total migration amount). Of all migration flows amount of population in Kyzylorda oblast 19.2% corresponds to international migration, inter-provincial – 34.5%, and provincial – 46.4%.

Aralsk and Kazalinsk rayons in 2000 constituted 9,9% and 13,3% of provincial amount of migrating population. Feature of Aralsk rayon is that for all considered period outflow exceeded inflow of population. In period from 1960 to 1990 in Aralsk rayon trend of emigrating population growth has been observed, during next 5 years amount of population leaving Aralsk rayon sustained at high level. From 1995 to present period number of migrants reduced.

Table 2.3.1
Distribution of migrants of Kyzylorda oblast on basic nationalities, (people)

	immigrants		emigrants		Migration balance	
	1999	2000	1999	2000	1999	2000
Total	3734	4813	6365	8459	-2631	-3646
Including:						
Kazakhs	3585	4612	5079	7600	-2124	-2988
Russians	60	78	353	471	-293	-393
Ukranians	6	6	26	26	-20	-20
Belorussians	-	-	2	5	-2	-5
Germans	4	3	30	40	-26	-37
Tatars	13	11	31	47	-18	-36
Uzbeks	2	20	9	18	-7	2
Azerbaijanis	3	6	2	4	1	2

2.2.4. Loss of personnel

Main reason of insufficient employment of population is limitation of labor implications. Existing branch structure in oblast has never provided maximal population employment. There is no large industrial enterprise, which could serve as core of industrial complex formation. There are substantial troubles with involvement of second and third family members in public production. Labor resources increment overtakes growth of job places' number. This has led to such social phenomenon as unemployment.

From 1960 to 1990 on territory of Kazakhstan Prearalie growth of labor resources more than twice from 163,7 to 344,3 th. people has been observed. Period 1991-1995 can be characterized by stability of indicators both in Kyzylorda oblast and Aralsk and Kazalinsk rayons. From 1995 to 2001 decline of labor resources' number from 351,5 to 319,1 th. people was noted, growth rates for this period were equal to 90%, i.e *loss of personnel occurs* in Kazakhstan Prearalie.

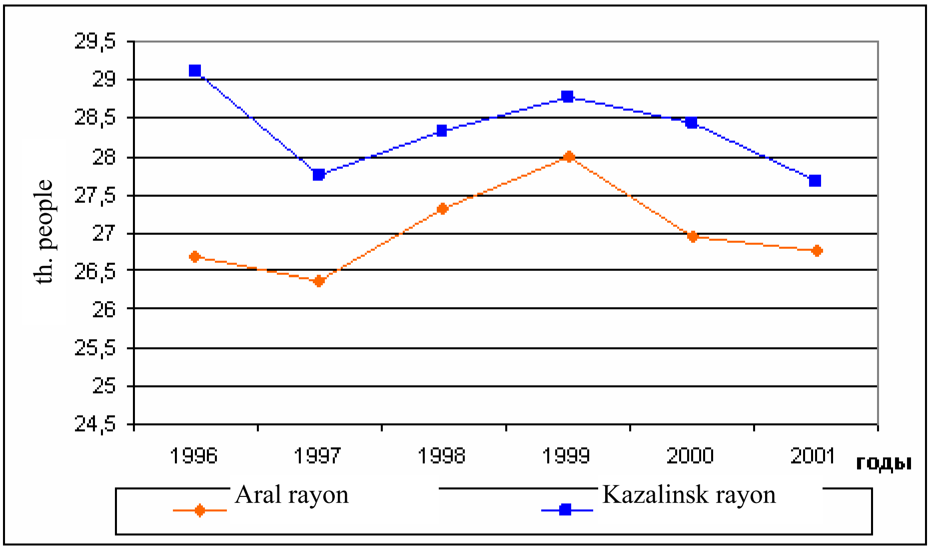


Fig. 2.2.4.1. Dynamics of population number dealing with economy of Kazakhstan Prearalie, th. people

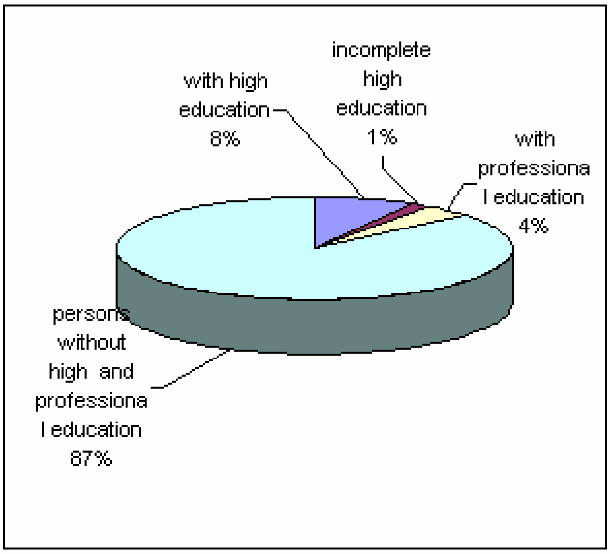
In Aralsk rayon growth of population number dealing with economy of rayon from 26.7 th. people in 1997 to 28 th. people in 1999. Since 1999 – decrease of population dealing with economy in Aralsk rayon to 26.8 th. people in 2001. In Aralsk rayon during 80-ties employment indicators were the lowest amongst all rayons of Kyzylorda oblast, and in rural region they were lower, about 40%.

Women employment in Aralsk is higher than men's. Reduction of industrial production reflected first of all on employment of male population, female labor can be applied in branches of non-production sphere.

In Kazalinsk rayon in period 1996-2001 tendency of population number decline that deals with agriculture from 29,1 in 1996 to 27,7 th. people in 2001.

Regarding agricultural direction of Kazakhstan Prearalie as rice production and stock-breeding region majority of people employed in economy corresponds to agricultural workers. From 1960 to 1975 growth of number of people employed in this grading branch of people economy. Number of people employed in agricultural production reached 50.1 th. people in 1975-85. Since 1985 till present days number of agricultural workers reduced to 11.9 th. people, almost 4 times, against beginning of study period – 3.5 times less.

In spite of reduction of labor resources during study period qualitative change of labor resources' structure occurred – education level increased. Population with high education increased for considered period in 1960 from 4.1 to 43.8 th. people in 2000 – 10.5 times, with professional education from 9.1 to 69.1 th. people, 10.7 times, appropriately. Share of persons having no above-mentioned education reduced from 86% to 51.6%, by 34.4%.



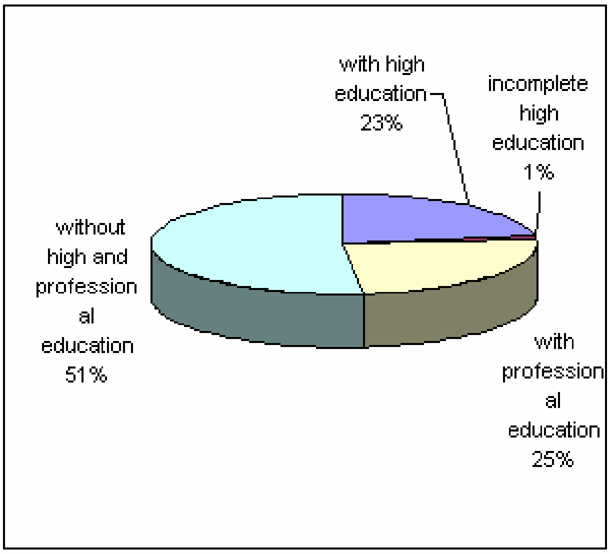


Fig. 2.2.4.2. Population educating level in age 15 years old and elder, %

Following conclusions can be made:

- Kazakhstan Prearalie can be always characterized by significant potential opportunities of labor resources' involvement in public production, but used insufficiently;
- In Kyzylorda oblast during considered period population employment in public production was the lowest over republic;
- since 1995 in region of Kazakhstan Prearalie decline of labor resources' number occurred, i.e. loss of personnel. It was related to population emigration from ecological disaster zone that led to direct losses of intellectual and qualified staff;
- last quarter of century is characterized by reduction of people employed in agriculture, industry, construction, transport, and communication;
- qualitative composition of labor resources related to population educating level increase has changed.

2.2.5. Damage to Health

Direct impact of social-economic situation aggravating as well as unfavorable environmental situation in Kazakhstan Prearalie is obvious in people health living in disaster zone, which is considered via indicators of birth rate, death rate, and population diseases rate.

Deterioration of residents' health of Prearalie was caused by following reasons:

- Decrease of low rates of social-economic development of Aral region and aggravation of living conditions of local population;

- Poor development of assets of public health system in Kazakhstan Prearalie;
- Unsatisfactory conditions of water supply and use of population;
- Aggravation of surface and ground water quality by toxic combinations, in result of human economic activity;
- Specific natural-climatic conditions of Kazakhstan Prearalie.

Since June 1995 in Kazakhstan trends of gradual decrease of death rate were outlined. Number of dead in 2000 against 1995 reduced on 19.8 th. people or on 11.8% and reached 148.8 th. people (death rate was 10.0 of dead per 1000 of population). In Kyzylorda oblast also death rate reduction was registered (14.8%). Death rate in oblast is lower than average republican and was equal to 7.4%.

Table 2.2.5.1
Death rate coefficient of population in Kazakhstan and Kyzylorda oblast
In dynamics per 1000 people

years	Kazakhstan, In total	Kyzylorda oblast, In total	Kyzylorda oblast, urban	Kyzylorda oblast, rural
1960	7,5	8,2	9,4	6,2
1970	6	5,3	6,1	4,4
1980	8	7,3	6,9	8,1
1985	8	6,8	6,6	7,1
1990	7,8	7,4	7,7	7
1991	8,2	7,7	8,1	7,1
1992	8,4	7,7	7,9	7,3
1993	9,5	8,2	8,5	7,7
1994	9,9	8,2	8,6	7,3
1995	10,7	8,9	9,3	7,6
1996	10,7	8,1	9,1	7,2
1997	10,4	7,8	8,4	6,9
1998	10,2	7,6	8,4	6,4
1999	9,8	7,4	8,0	6,4
2000	10,0	7,4	8,1	6,3

As before in Kyzylorda oblast diseases related blood circulation system, which share was 42.2% of total number of dead in 2000, play decisive role in death reasons. Also dead in result of diseases of lungs 11.8% (12.4% in 1999) and from malignancies 12.4% against 13.4% in 1999 /121/ take significant place. Specific weight of dead from diseases of lungs as well as in result of infectious and parasite diseases in oblast is almost 1.5-2 times higher that average republican indicator 11.8% against 7.3% (share of dead in result of lungs diseases) and 8.1 against 4.8 (share of dead in result of infectious and parasite diseases), appropriately.

In Kyzylorda oblast, Aralsk and Kazalinsk rayons population death rate indicators in result of lungs diseases and infectious and parasite diseases are higher than average republican and, moreover, on these reasons of death in 2000 oblast took the first place among all oblasts of Kazakhstan, and death rate indicators in considered rayons exceed 1.5 times provincial and twice – average republican.

Table 2.2.5.2
Population death rate in Kyzylorda oblast on reasons of death per100 000 people for 2000

Reasons of death	Aralsk rayon	Kazalinsk rayon	Kyzylorda oblast	Kazakhstan
Total number of dead on all reasons	852,18	858,59	739,13	1001,01
including				
Blood circulation system	365,58	357,17	316,59	500,50
Accidents	59,65	66,97	93,47	140,73
malignancy	143,17	86,72	96,98	154,13
Lungs' diseases	107,38	170,86	84,04	71,06
Infectious and parasite diseases	78,4	64,39	50,07	34,07
Other reasons	98	112,48	98,30	125,76

*Calculated on data of Kyzylorda oblstatupravleniye for 2000;

High indicators of population death rate in result of such reasons of death as lungs' diseases, infectious and parasite diseases are direct reflection of unfavorable environmental situation, unsatisfactory quality of water supply, and naturally, low level of medical service.

Table 2.2.5.3
Indicators characterizing population health in Kazakhstan and Kyzylorda oblast ($^0/_{00}$)

rayons	Birth rate		Death rate		Infant death rate	
years	1960	2000	1960	2000	1960	2000
Aralsk rayon	31,9	21,3	9,0	7,4	56,9	20,1
Kazalinsk rayon	36,8	23,3	8,2	7,8	27,8	21,4
Kyzylorda oblast	37,1	20,7	8,2	7,4	32,0	22,7
Kazakhstan	37,2	14,6	6,6	10,0	36,4	19,2

Main reasons of infant death rate is weakening of women organism and in connection with that sharp aggravation of health caused by critical environmental conditions of life. In 2000 infant death rate indicator was 22.7 $^0/_{00}$ that is higher than average republican (19.2%).

Since 1995 tendency of death rate reduction in general can be observed and infant, in particular.

Life expectancy of population in Kazakhstan Prearalie is lower than supposed life expectancy of population on average over republic.

For considered period from 1960 to 1995 tendency of supposed life expectancy reduction emerged both in Kazakhstan Prearalie and Kazakhstan in general.

In Kyzylorda oblast total life expectancy reduced from 70.8 to 62 years, on 8.8 points, men – from 66.2 to 58 years, women – 74.6 to 66.4 years. Since 1995 general tendency of life expectancy increase can be observed. This fact can be explained by that migration process has decreased by that moment, and rest part of population, 99% of aborigines, which have adapted to local conditions of life. Population life expectancy of Kazakhstan part of Prearalie is specific barometer for aggravation of social-economic and environmental conditions forming in region.

2.2.6. Morbidity in Prearalie

Diseases of local population are directly connected with pollution of soil and water with toxic substances came from economic activities. Application of fertilizers and pesticides in the amounts that exceed permissible norms is accompanied by their removal through surface and drainage flow. This considerably impacts the quality of water in the Syrdarya basin.

Within the framework of the research we have collected and analyzed statistical data on morbidity and mortality in the region for 2000.

Mortality due to respiratory system diseases was highest in the region in 2000 compared to the whole republic and was 108 against 81 per 100000; rate of respiratory system diseases also was high in the given region, amounting to 20128,9 per 100000. Kyzylorda oblast takes second place (after Mangistauskaya oblast) regarding morbidity due to infectious and parasitic diseases (50,07 per 100000), while it was 78,4 per 100 000 people in Aralsk rayon and 64,4 per 100 000 in Kazalinsk rayon. Rate of these diseases was highest in Kyzylorda oblast and reached 4316 per 100 000 against 2444,2 per 100 000 all over the Republic of Kazakhstan.

In 2000, Kyzylorda oblast took first place among Kazakhstan's oblasts regarding rate of such diseases as hemopathy and blood-forming diseases, blood circulation system diseases, and dermic and hypodermic diseases.

From 1997 to 2000 rates of the following diseases increased: hemopathy and blood-forming diseases - from 3585,5 to 5020,4 per 100 000 people or by 40%; blood circulation system diseases - from 1363,2 to 2137,1 per 100 000 or by 56,8%; neoplastic diseases - from 293,3 to 341,6 per 100 000 or by 16,5%, particularly in Aralsk rayon that results from the adverse environmental conditions; eye and its adnexa diseases - from 1761,6 to 2654,8 per 100 000 or by 50, 1% that can be explained by the influence of dust and salt transfer; ear diseases - from 1797,4 to 2450,1 per 100 000; respiratory system diseases - by 23,1%; urogenital diseases - 1,4 times higher; and, musculoskeletal system diseases - 1,2 times.

A set of factors has formed in the process of man-made desertification that cause epidemiological crisis in Kyzylorda oblast. The following factors are dominant:

– **Many various sources of infection are available** due to long-term high level of morbidity, which does not tend to decrease and creates high risk of infection for all social groups. There remains a very tense situation regarding viral hepatitis and other enteric infections. A plausible reason is wide spread water, food, and communicative-domestic transmission of the diseases.

– **Unsatisfactory water supply and use**, lacking disposal and neutralization of wastes and sewage water have caused quite adverse sanitary conditions that promote spreading of enteric infections. This is confirmed by sanitary-bacteriological and chemical studies conducted for the most important components of the environment: various water sources and soil at food enterprises, catering network, child institutions and schools.

– **Specific natural-climatic conditions of Kyzylorda oblast** exert substantial influence on spreading of enteric infections by affecting mechanism of their transmission. Such conditions include prolonged dry period, low precipitation, shallow water table, pronounced corrosive groundwater that causes short life and constant accident risk for buried pipeline.

– **Active interference of man's activities** expressed in intensive water diversion from vital natural bodies - the Aral Sea and the Syrdarya river – has increased their epidemic hazard due to reduced self-purifying ability, which is confirmed by high content of enteric bacterium, including pathogenic one, unfavorable physical, chemical and organoleptic properties of water in above-mentioned water bodies.

Under progressive man-made desertification above negative effects may intensify if appropriate restricting measures are not undertaken.

– **Strong pollution of water sources and soil** is determinant in keeping quite high rate of enteric and viral infections; water-transmitted enteric infections are still widespread and greatly damage population health and economy. For a long time this has been proven by mass spreading of viral hepatitis, typhoid and paratyphoid, acute dysentery and other enteric infections.

The highest rate of acute enteric infections (AEI) is observed in Kyzylorda oblast as well. In 2000 it exceeded 1,6 times average rate throughout the Republic and amounted to 381,1 per 100 000. Prevalence of acute enteric infections was fixed in Kazakhstan's part of Prearalie in 1965. Relevant indicators were as follows: 1413,6 per 100 000 in Kyzylorda oblast against 1163,2 per 100 000 in the Republic as a whole; 1065 per 100 000 in Aralsk rayon; and 974,3 per 100 000 in Kazalinsk rayon. Downward tendency of AEI had been observed till 1985 both in the Republic as a whole and in Kazakh part of Prearalie. Over the last decade maximum rate of AEI diseases was observed in Kyzylorda oblast in 1997 – 821,1 per 100000 population, that has exceeded the republican indicator 2,5 times. The minimum was in 2000 – 381,1 per 100000 population. Since 1997 the tendency towards the decrease of AEI has taken shape both throughout the Republic and in the oblast.

Rate of tuberculoses is still highest in the oblast against its growth in the Republic as a whole. The year 1994 was a threshold in this respect when incidence of this disease increased generally.

Rates of other diseases, such as respiratory infections, digestive system diseases, uro-genital diseases, some illness during perinatal period, are also higher than republican ones.

Unfavorable situation regarding infant morbidity reflects the critical ecological situation in the region, the low socio-economic conditions, the poor material and technical basis of healthcare system, as well as indicates to poor health of parents who pass on many kinds of diseases.

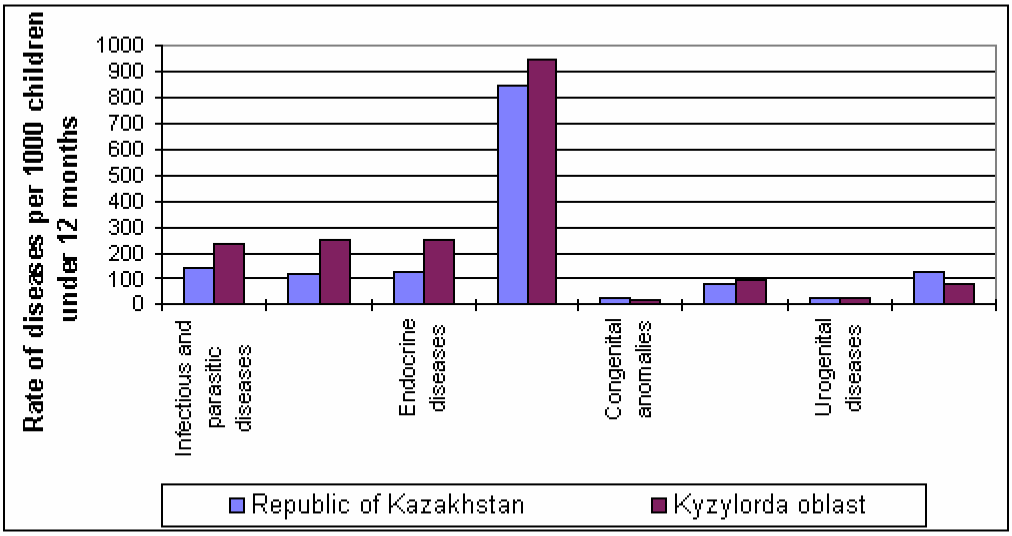


Fig.2.2.6.1. The rate of diseases in children under 12 months in 1997

2.2.7. Deterioration of living conditions

The main indicators of living standards are cash income, wages, subsistence minimum, average pension, as well as human development index, which is considered as integrated assessment of the development and use of human potential.

In early 90-ties there was downward tendency in living standards because of objective difficulties of the transition period.

2.2.7.1. Population's incomings

Data on the basic indicators of living standards are considered only within Kyzylorda oblast since data at rayon level are not available.

Before 1996, cash income had been the lowest in the Republic due to prevalence of employment in low profitable agriculture. Last years cash income has increased in Kyzylorda oblast and even exceeded average republican income due to development of oil industry in the oblast.

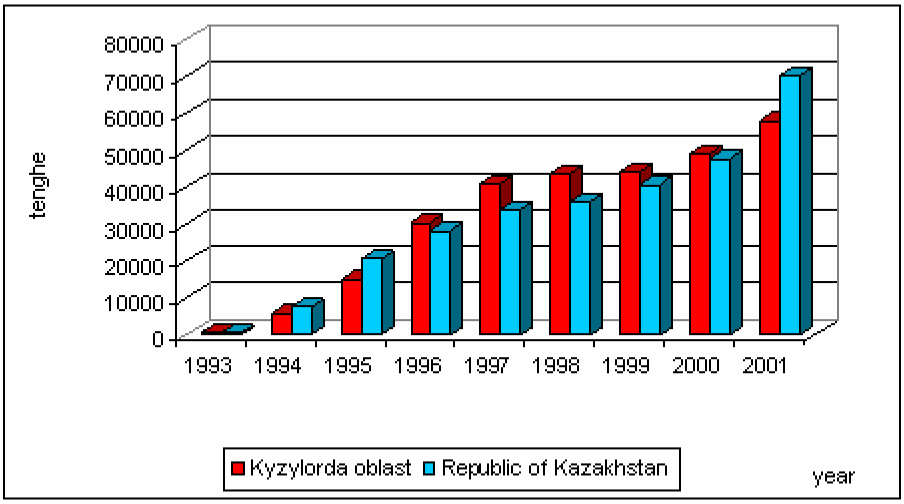


Fig. 2.7.1.1. Per capita income in the Republic of Kazakhstan and in Kyzylorda oblast (national currency - tenge)

However in currency equivalent per capita cash income decreased twofold from 1960 to 2000 both in Kyzylorda oblast and in the Republic as a whole. For the given region per capita cash income amounted to $645,65 in 1960 and $387,4 in 2000, while in the republic it was $904,35 and $467,83, respectively.

Major portion of cash income was comprised of incomings from labor activity, i.e. of wages (69%). Social transfers (pensions, scholarships, aid) reached 13%, income from other selling was 15%, and other receipts amounted to 3%.

In 2001 average monthly wage was lower (14217 tenghe) in Kazakh Prearalie than in the Republic (17918 tenghe) and formed 79.3% of average republican value. In 1999 wages were lower in Aralsk and Kazalinsk rayons than average oblast ones (10310 tenghe or $74,6) and formed 82% (8453 tenghe or $61.2) and 84% (8652 tenghe or $62,6), respectively. Over 1993-2001 there had been observed an increase in wages in Kyzylorda oblast and in the Republic.

Over forty years average monthly wage (in currency equivalent) had reduced from $156.1 in 1960 to $94,65 in 2001 in Kyzylorda oblast and from $177,2 to $119,29, respectively in the Republic as a whole. Over 1960-1990 we have observed stable growth of wages. Maximum average monthly wage at $265.4 for the republic and at $231.7 for Kyzylorda oblast was reached in 1990.

Thus, in Kazakh Prearalie wages (in currency equivalent) have not reached the level of 1975 yet, while in 1990 the amount of wages was 2,5 times higher than at present that is directly connected with population incomings. These data confirm that socio-economic conditions deteriorate in Kazakhstan part of Prearalie.

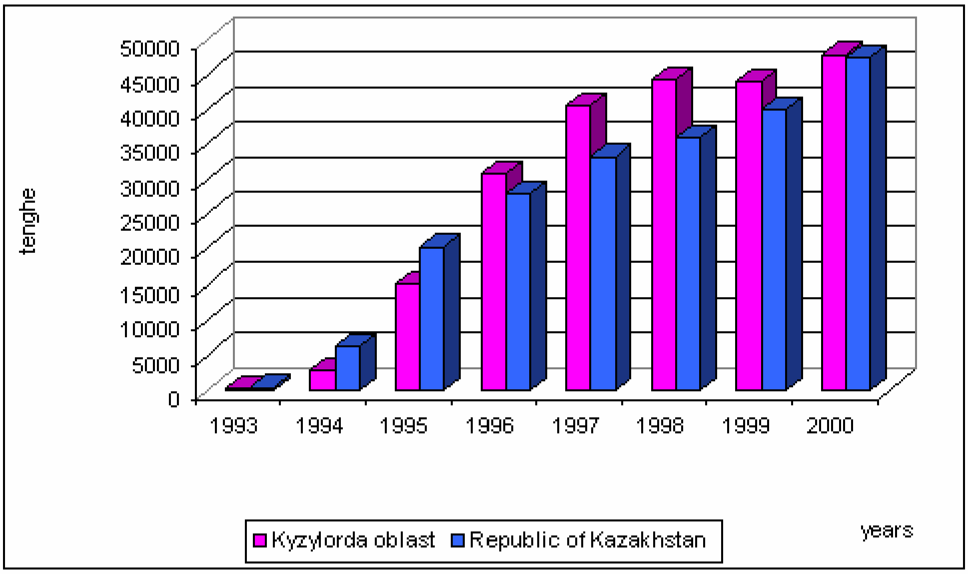
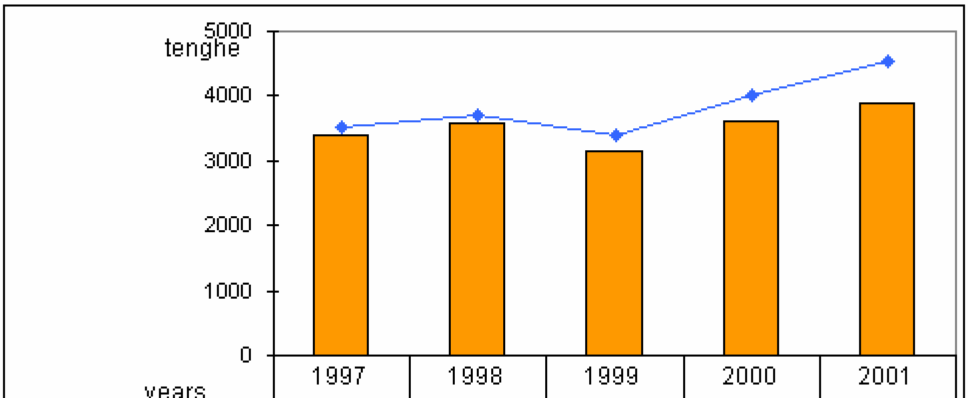


Fig. 2.2.7.1.2. Per capita costs in the Republic of Kazakhstan and in Kyzylorda oblast (in tenge – national currency)

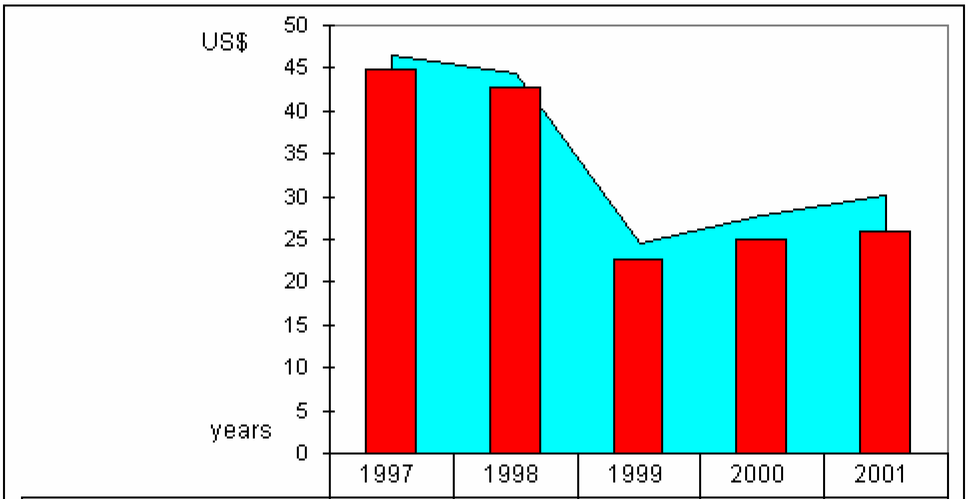
The following costs prevailed in surveyed families of Kyzylorda oblast in 2000: food (54%); nonfoods (22%); taxes, dues and fees (7%); services (14%); other costs (3%). In 2001, subsistence minimum was 3896 tenghe per capita in Kyzylorda oblast against average republican one at 4532 tenghe.



years	1997	1998	1999	2000	2001
Kyzylorda oblast	3394	3579	3147	3605	3896
Republic of Kazakhstan	3505	3716	3394	4007	4532

Fig. 2.2.7.1.3. Dynamics of the average subsistence minimum for the republic in general and for Kyzylorda oblast (in tenge)

This indicator grows in national currency but it falls down in currency equivalent both in given region and in the republic in general due to inflation. This indicates to deterioration of socio-economic situation as a whole.



	1997	1998	1999	2000	2001
Republic of Kazakhstan	46,39	44,31	24,56	27,73	30,17
Kyzylorda oblast	44,92	42,67	22,77	24,95	25,94

Fig. 2.2.7.4. Dynamics of the per capita subsistence minimum in average in the Republic of Kazakhstan and in Kyzylorda oblast (in US$)

Thus, socio-economic conditions for forty-years period in Kazakhstan's Prearalie as well as in the Republic as a whole may be considered in stages.

The first stage (1960-1990) – growth and stability of socio-economic indicators.

The second stage (1991-2000) of change-over and economic reforms, which was characterized by decreased cash incomes, reduced wages, lowered pensions, reduced benefits and compensations, decreased GDP per capita and subsistence minimum.

2.2.7.2. Consumption of foodstuff

Decrease in per capita consumption of foodstuff in Kyzylorda oblast and in the republic in general over the last decade has been resulted from degradation of socio-economic situation in the country as a whole and particularly in Kazakh part of Prearalie and consequently from the reduction of incomings and purchasing capacity in the region.

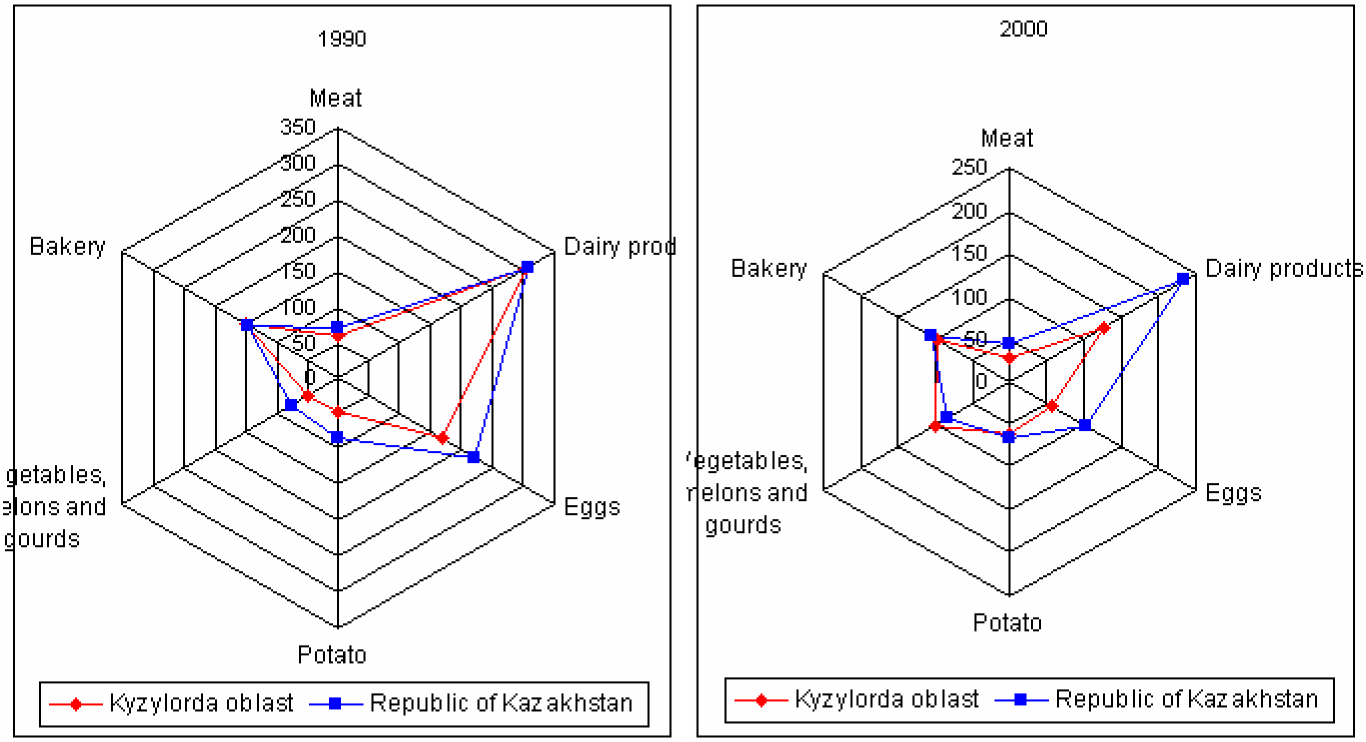


Fig. 2.2.7.2.1.Per capita consumption of foodstuff in the Republic of Kazakhstan and in Kyzylorda oblast

The oblast produces products 1,5-2 times less against rational need according to norms developed by Food Institute of the Republic of Kazakhstan. Food supply in quite inadequate. Food consumption does not correspond to physiological norms, and great portion of populations suffers from protein and vitamin deficiency. Food consumption in Kazakhstan's Prearalie is the lowest almost for all basic products, except for vegetables, melons and gourds and bakery.

2.2.8. Conclusions to Chapter II

Based on conducted analysis, the following may be concluded.

Prearalie is the zone of the most critical socio-economic conditions in Central Asia.

Diseases in the region are mainly caused by poor water quality, climatic changes, and malnutrition due to low incomings. As a result, the region shows higher childhood and infant mortality, as well as population mortality. Analysis of data on the rates of viral hepatitis and acute enteric infections in Kyzylorda oblast and on the contents of pesticides and phenols in waters of the Syrdarya river confirmed the role of water factor in the spreading of viral hepatitis, typhoid, and dysentery in population.

As to wages in currency equivalent, Kazakhstan's part of Prearalie has not reached the level of 1975 yet, while in 1990 the amount of wages was 2,5 times higher than at present.

During new economic reforms, since 1990 there has been observed prevalence of Prearalie population's costs over incomings. This may be explained by imperfect and unstable economic reforms and development in the region.

This circumstance explains the low socio-economic level of population living in ecological disaster zone and that the most population lives on the verge of and below the poverty line.

Comparison of the nutrition structure and norms shows that consumption of all types of foodstuff, excluding potato, in given regions is lower than throughout the republic. The main cause is the reduction of incomings and the growth of difference between supply and ability to purchase food.

Inadequate food supply, low quality of housing resources, reduction of schools and kindergartens, and poor material and technical base of healthcare system have led to fall in standards of living on the background of deteriorating environmental conditions. Worsening of socio-economic situation in the region directly influenced the demographic conditions in Kazakh part of Prearalie that appeared in decreased birth rate and natural increase, reduced population, less life expectancy, increased migration flows, risen morbidity and infant mortality, etc.

The state of irrigated agriculture is critical in given regions though over last few years certain betterments have been outlined. Analysis of yield data from 1960 determined that basic crops yields have been declining in Prearalie since 1980. Comparison of yields drop among rayons of Kazakhstan's Prearalie shows that maximum drop took place in Kazalinsk rayon, where decrease in yields of all analysed crops is several times more than average figures throughout Kyzylorda oblast.

Thus, general tendency for development of agricultural lands in the Syrdarya delta and their current state indicate to degradation of irrigated agriculture, which becomes apparent in the decrease of agricultural area, crop yields and productivity.

Analysis and evaluation of agricultural activities in Kazakh part of Prearalie over 1960-2001 show that cropping patterns and methods of land utilization completely depend on drainage characteristics of the Syrdarya delta and on its water supply, as well as on the state of farms' material and technical base, but not on the Aral shrinkage.

Drop of the Aral Sea level has affected the development of pastures: decrease - from 1985 to 2001 - of watered pastures by 25% in Aralsk rayon and more than twofold in Kazalinsk rayon was resulted from the drop of groundwater level and the increase of groundwater salinity. Over pasturing on watered pastures promoted the reduction of yields and forage stock and the loss of biodiversity. Last decade due to abrupt increase of livestock production on Prearalie pastures a tendency has taken shape for restoration of pasture ecosystem capacities.

Changes in hydrological regime in the Syrdarya delta and lake systems of Prearalie have direct effect on the state of grasslands: by 1985-1991 their area had reduced almost 5 times, while yields decreased 4 times. By 1990, semihydromorphic ecosystems had been on the verge of disappearance. The increase of water releases and the reduction of anthropogenic load led to some stabilization of grassland; however, all-round intensification of solonchak development highly restrains restoration processes in delta ecosystems.

Conducted analysis allows us to conclude that cardinal decrease of livestock productivity has began in Prearalie since 1985 and, more paradoxical, that rates of decrease for many indicators are higher in Kazalinsk rayon than in Aralsk rayon. This suggests that the main cause of the sector degradation is general deterioration of socio-economic conditions in the region but not shrinkage of the Aral Sea.

Flow regulation in the Syrdarya and Amudarya rivers and water intakes for agricultural needs have entailed drop of the Aral Sea level. Till recently fish industry had been one of the sectors of regional specialization, but currently it completely has lost its leading position and fallen into decay. Fish catch in the lakes of Syrdarya lower reaches started to fall down after construction of Shardara dam. At present only plaice is found in the Aral Sea. However, according to ichthyologists' data it is on the verge of disappearance since its hard-roe suffers from increased water salinity.

Currently only two lake systems, such as Kamyslybasskaya and Akshatauskaya and partiallt Aksay-Kuadarinskaya are significant in terms of fishery. However number of the main food fish – sazan and bream – has considerably reduced and number of roach, predators and rough fishes has increased in retained lakes.

Fish and fish products are the main food and sometimes the primary income of local people.

Over many years people of Prearalie has been suffering from serious environmental and socio-economic problems and most of all from poor quality of drinking water. Fishery and paper industry, development of which was dependent on fish and reed as on raw material have disappeared thus leaving thousands of people without livelihoods.

III. BASIC PROVISIONS FOR EVALUATION OF MEASURES ON DAMAGE REDUCTION IN PREARALIE

Given report is based on RS and GIS data analysis since 1960 to date in water surface, landscape, and soil changes performed by T. Budnikova and summarized in Report-2003 complemented by field expedition made by I. Ruziev and V. Bensman as well as analysis made by Prof. N. Kipshakbaev and other executors.

Taking into account morphological peculiarities and water recharge principles, accepted in WB project «Syrdarya river and Small Aral Sea regulation» (Association GES/SOGREAH/Kazgiprovodhoz), all territory under study has been divided into 4 zones (fig. 3.1):

Zone "a" – **Coastal part** (fig. 3.1.1) including Syrdarya mouth (25 km) and dried bed zone from the dam around Northern sea.

Zone "b" – Maritime lake system of lower delta being under impact of Aklak water-work destroyed later and has to be rehabilitated (fig. 3.1.2).

Maritime system covers Syrdarya river reach 44 km long with provisional artificially created left bank lake system functions including Zhilandi, Zhulduz, Bayan, Kartma, Akboget, Karakol, Uchaidin, Akbasti and canal network: Tangzharma, Kushbanzharma, Kizketken, Zhilandi, Karatereng-1, karatereng-2; and right bank lake system including lakes Karashlan, Shoshka-Aral, Domalak, Akkol, Tusebas, Sarteren and canal network: Saginbai, Domolak, Akkol, Balgabai.

Zone "c" – Middle delta (fig. 3.1.3) with river reach 145 km long with two lake systems: right bank Kamislibas including lakes Kamislibas, Laikol, Kayazdi, Zhalanashkol, Raimkol and canals: Kulager, Kul, Zhaslan, Sovietzharma; left bankи Akshatau lake system: Shomishkol, Karakol, Akshatau, Sorgak and canals: Shomishkol, Beszharma, Tabeken, Akkoi, Akshakiz, Siukkol. This part of delta locates in backstopped zone from Raim water-work.

Zone "d" – Aksai-Kuandarya lake and wetland system (fig. 3.1.4) consisting of two chains of lake in former Aksaidelta and along Kuvandarya. First chain consists of lakes Sarikol, Zhubai-Sadirbai, Lahankol, Zhanai; second - Akkol, Maryamkol, Ubakkol, Ishankol, Kurdimkol, Kojamberdi, Tosti, Shurke. This territory is supplied from two sources: Aksai water intake takes water from Kazalinsk water-work anda Kuvandarya takes water from Kyzyl-Orda irrigation massif.

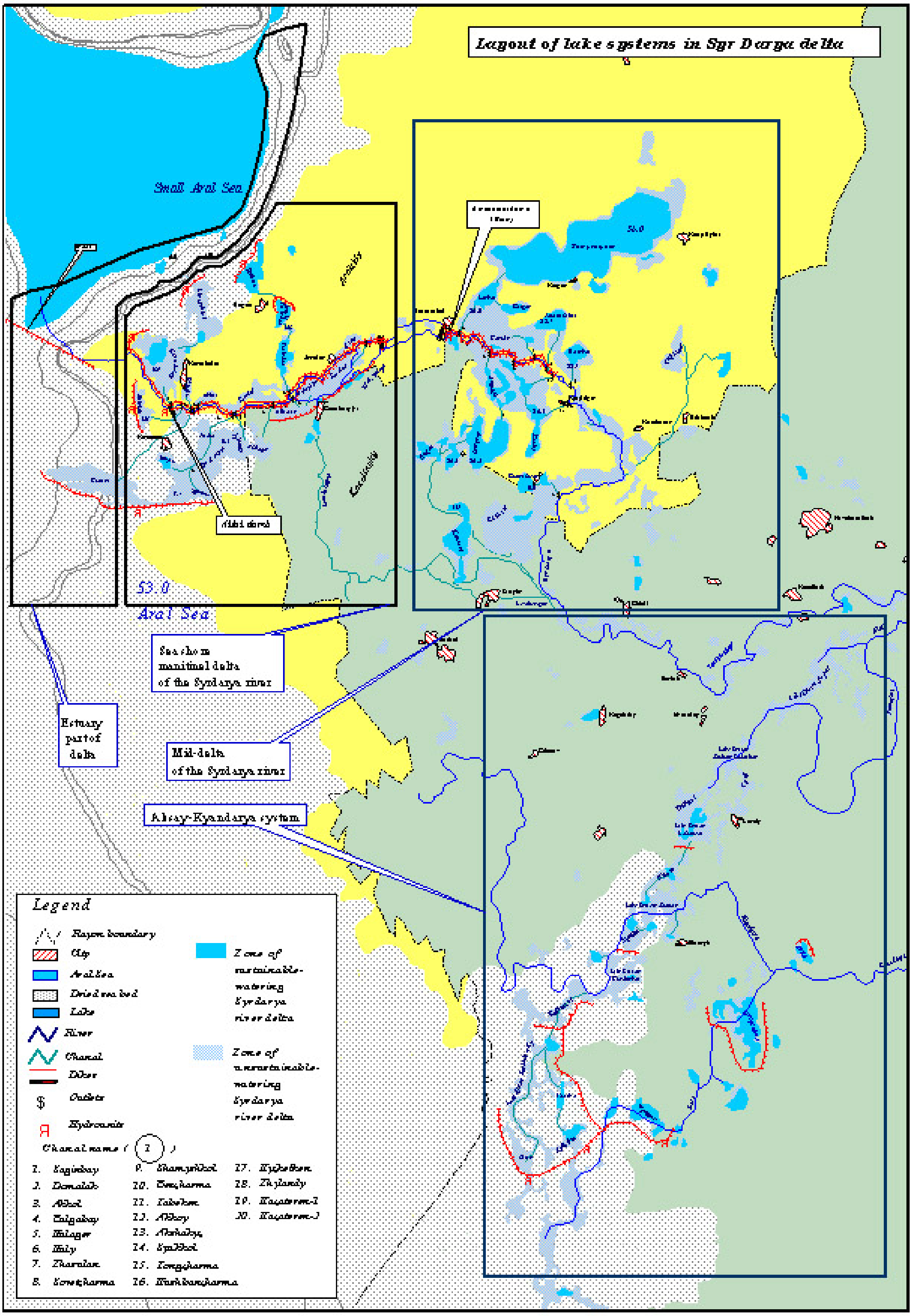

Layout of lake systems in Syr Darya delta
Small Aral Sea
Aral Sea
53.0
Sea shore marginal delta of the Syrdarya river
Estuary part of delta
Mid-delta of the Syrdarya river
Aksay-Kyandarya system
Legend
Rayon boundary
City
Aral Sea
Dried sea bed
Lake
River
Channel
Dike
Outlets
Hydrounits
Zone of sustainable-watering Syrdarya river delta
Zone of unsustainable-watering Syrdarya river delta
Channal name
1. Kaginbay
4. Zaigabay
7. Zharalan
10. Zengharma
12. Akkoy
14. Syalkol
17. Kyzketken
18. Zhylandy

Fig. 3.1

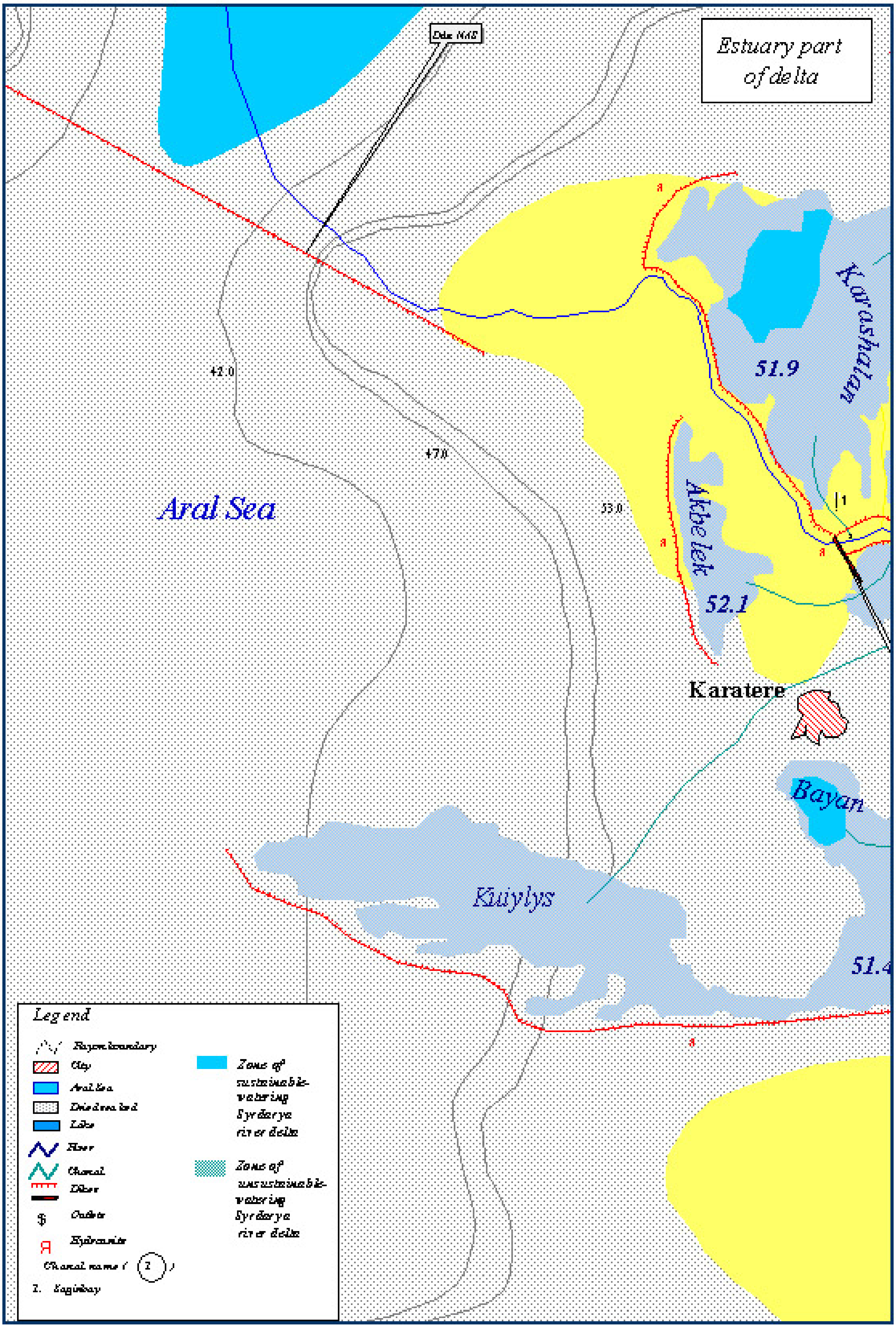

Estuary part of delta
Aral Sea
42.0
47.0
53.0
Karashalan
51.9
Akbelek
52.1
Karatere
Bayan
Kuiylys
Legend
Zone of sustainable watering Syrdarya river delta
Zone of unsustainable watering Syrdarya river delta

Fig. 3.1.1

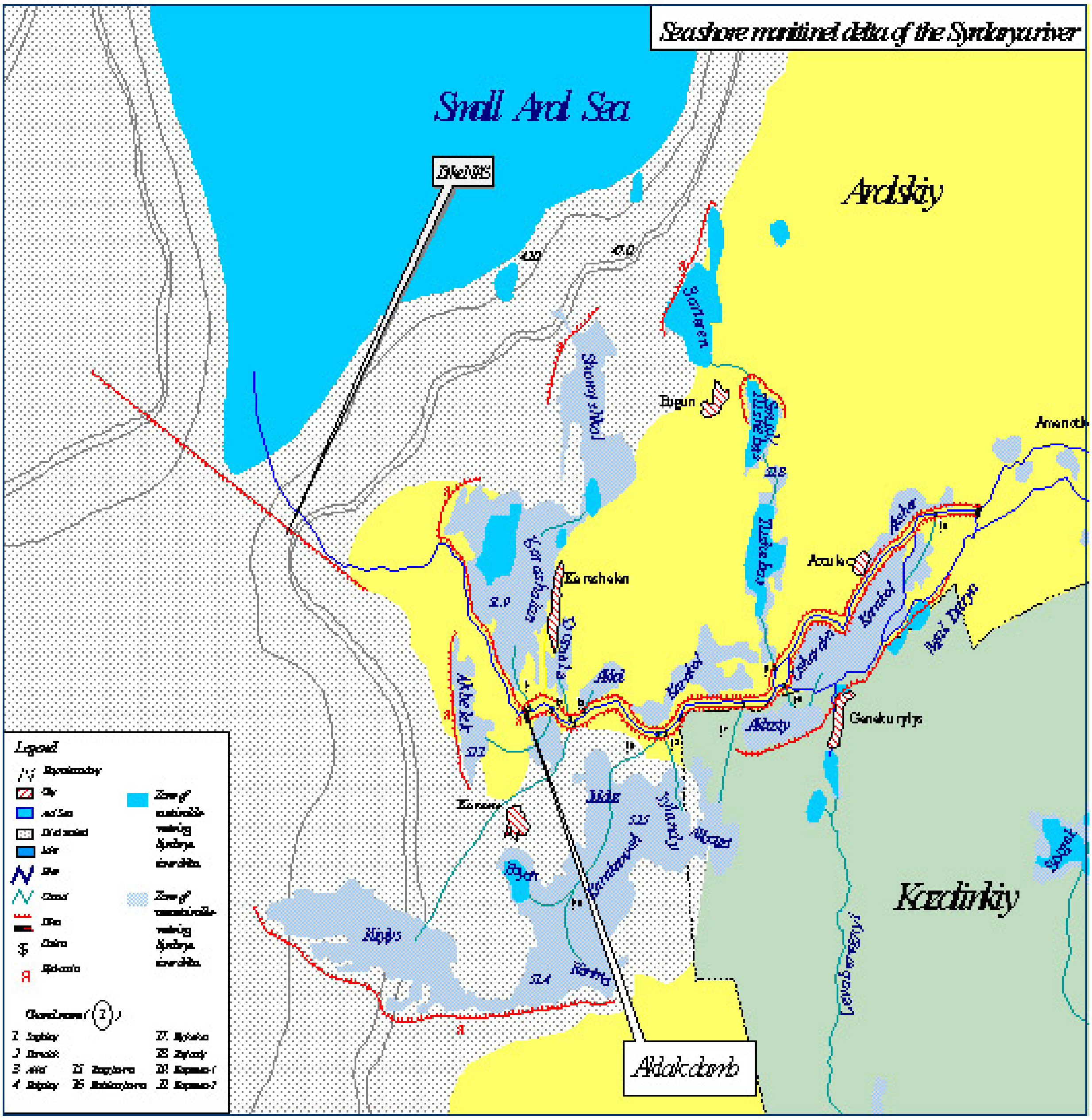
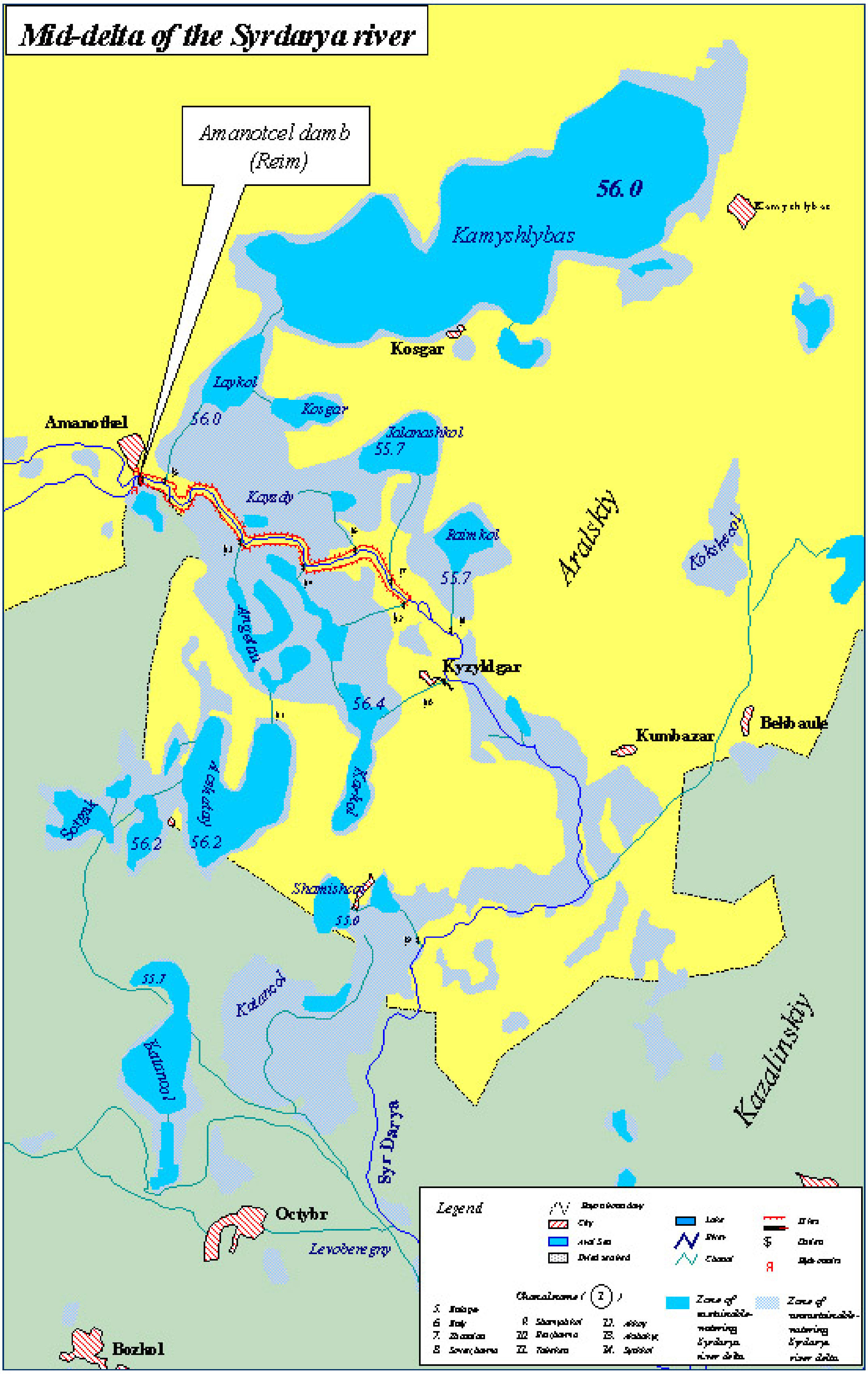


Fig. 3.1.2



Mid-delta of the Syrdarya river
Amanotcel damb (Reim)
56.0
Kamyshlybas
Kosgar
Laykol
56.0
Kosgar
Amanotkel
Jalanashkol
55.7
Kayzdy
Reimkol
55.7
Aralskiy
Kokshekol
Kyzyldgar
56.4
Kumbazar
Bekbaule
Sorsak
56.2
56.2
Shamishcol
55.0
55.7
Karakol
Syr Darya
Kazalinskiy
Octybr
Levoberegny
Bozkol
Legend

Fig. 3.1.3

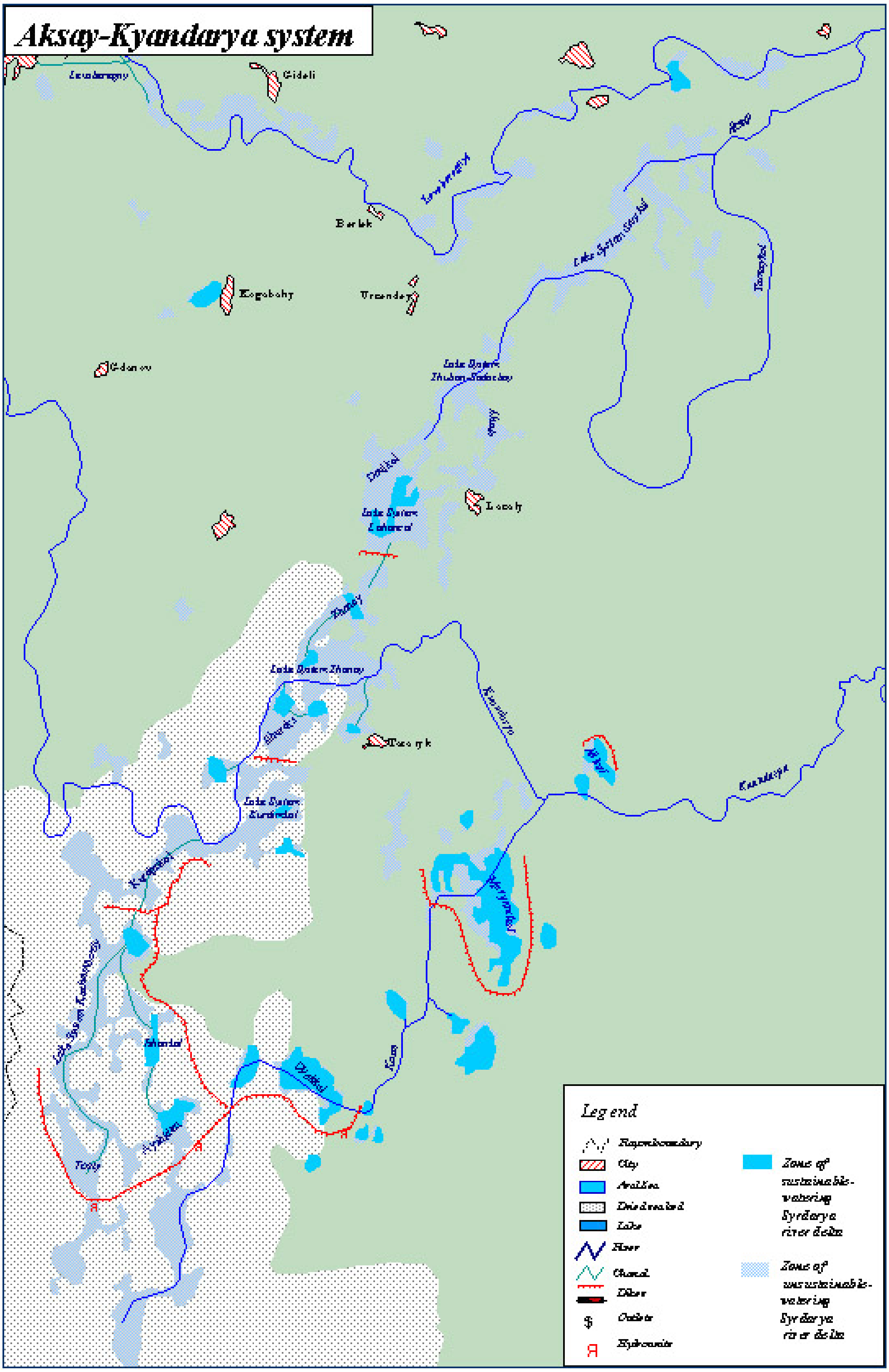


Fig 3.1.4

Current water-related situation in Syrdarya delta is determined by inflow changes to upper delta -Kazalinsk (fig.3.2-3.3) and flow use dynamics and state of hydraulic structures.

In 1987 Aral Sea started to divide into two parts: Small (Northern) and Big (Southern) sea.

Berg threshold is important element of submarine relief being flat elevation made of sands and sandy loam 14.0-15.0 km and 17,0-17,5km. Located at altitude of 42-41m, Berg threshold is a natural barrage for water overflow from Small to Big sea. In Small sea due to inflow from Syrdarya positive water balance begun to form, excessive water through Berg threshold came to Big sea. By 1992 level difference between two seas was near 3 m: Small sea – 40.2 m, Big sea – 37 m. About 33 th. km^2 of former seabed has been dried up with its maritime relief.

In 1993 Kokaral earthen dam but in 1994 it was destroyed. Next stage of construction (ridge altitude was 43.5 m) was started in 1996. By spring 1997 water level reached 41.25 m but dam was destroyed again. Due to this event, water level in Small sea decreased to 41,25m and again dam has been destroyed. In fall of 1997 rehabilitation works have been started. Dam ridge had to be risen up to 43.8m but dam has been destroyed third time.

Water level decrease in Small sea led to channel processes activation due to erosion basis lowering; internal lakes recharge became more difficult and even impossible.

Syrdarya channel within modern delta 189 km long provides up to 490 m^3/s water to the Aral Sea on average, 60 m^3/s was spent for delta watering.

With irrigated farming expansion in Syrdarya valley, delta ecosystem water availability issue emerged. In 70-es two water works were built regulating water supply by gravity to deltaic lake systems and to irrigation massifs.

Earthen Amanotkel dam with ridge altitude of 66,5 m built in 1976 closed main channel and canal Malenky. Water was released through open outlet 85 m width and tubular weir with threshold level 55,0m and discharge 19,30 m^3/s under water level in upper bay 55,25 m and maximum discharge 216 m^3/s under water level in upper bay 56,25 m. Amanotkel water-work provided command level in the river for lake system watering both on the right bank (Kamislibas) and left bank (Akshatau). In 1988-1989 Amanotkel structure has been destroyed by peak flow and has been not rehabilitated.

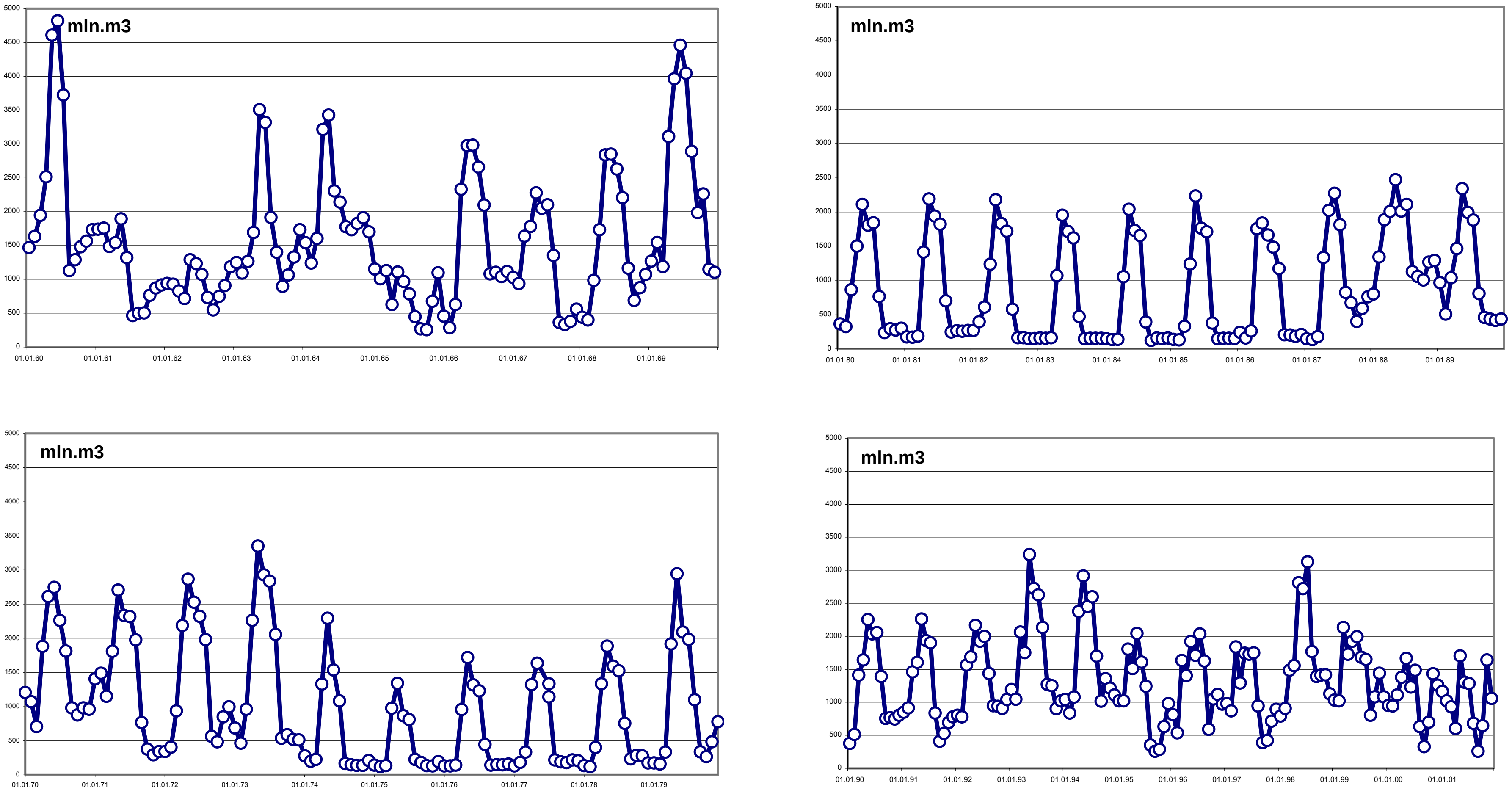


Fig. 3.2. Water volume in Chardara reservoir lower gauging site (mln.m^3) for 1960-2000

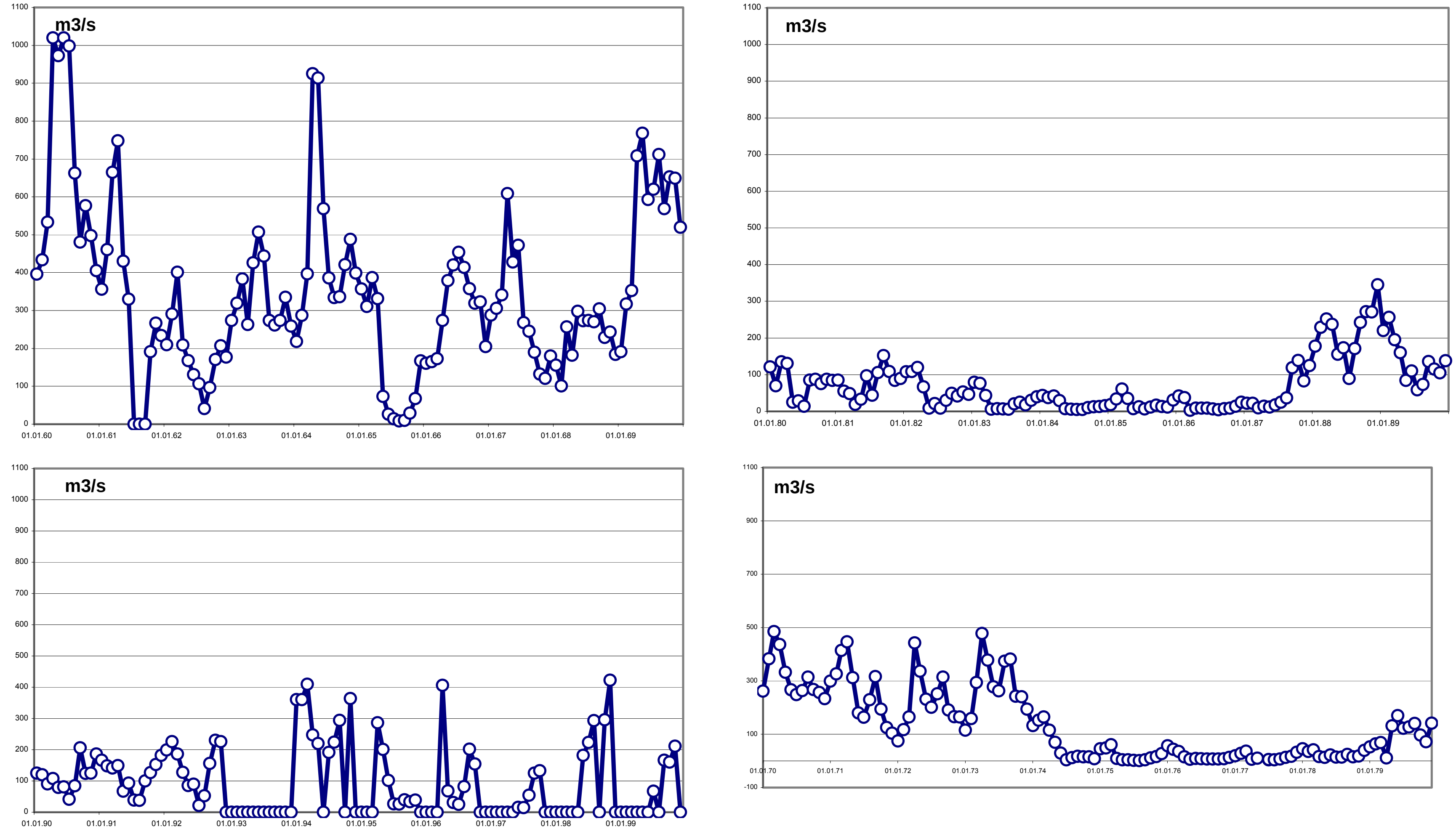


Fig. 3.3. Syrdarya discharge by Kazalinsk site for 1960-2000, m^3/s

Aklak dam built in 1975 was located at 25km from the Aral Sea. Earthen dam had length 350 m and ridge altitude 53,0 m was equipped with 5 sliding gates 2x2m and regulating outlets. Maximum outlet discharge was 70,5 m^3/s under water level in upper bay 51,5 m and minimum discharge 16,0 m^3/s under water level 49,5 m. Water-work provided water supply by gravity to natural depressions except lake Tushebas called also maritime lake systems (right and left bank).

Akmonatel and Aklak dams provided stable water regime in delta during 1975-1987. In this period near 2,5 km^3/yr were supplied including 1,0 km^3/yr for economic needs, 0,6 km^3/yr for lake system recharge, 0,9 km^3/yrcame to the Small Aral Sea (with deviation of 0,4 to 4,0 km^3/yr) and overflow to the Big Aral Sea.

In result of sharp increase of surface runoff to Syrdarya lower reaches in 1988 году (up to 5 km^3/yr) and limited capacity of hydraulic structures water regime in delta became unstable that influenced lake system and delta water availability.

In time if high peak flows in 1993 (7,5 km^3/yr) and 1994 (8,46 km^3/yr) left part of Amanotkel dam has been destroyed and its command position has been lost. Since this moment channel processes became more active. Channel deep erosion, according to Institute of Geography of Karakalpak Academy of Science, amounted for 0.5m during the period of 1994-1996 and its capacity increased by 2,5 and 1,28 times, respectively [2]. Presently, Amanotkel dam is destroyed.

Peak flow release to Syrdarya delta in middle of 90-es led to repeated channel breach around Aklak structure. Local population these sites were closed by earthen dams but tubular outlet is emergency situation. Presently, Aklak water-work does not function more and water release is performed through the right bank branch with active deep and side erosion as well as bifurcation.

In connection with lack of water supply to Syrdarya lowlands, ecological situation in deltaic lake system aggravated. Before extensive water diversion for irrigation, total lake (more than 500) area amounted for 1500 km^2 [3]. Lakes covered more than 7% of delta. There were 28 lakes with average size 10 km^2, lake Kamislibas area was 178 km^2. Kamislibas, Akshatau and Maritime systems are the biggest in the delta recharged from Syrdarya through Amanotkel and Aklak water-works built in 1975-1976.

After hydrostructures functioning completion water level in lakes is determined by releases from Kazalinsk water-work. Water supply to Kamislibas and Akshatau lake systems is made through right and left bank mains 108 and 66 km long with discharge in head 28,1 and 7,0 km^3, respectfully.

River flow increase since 1988 and peak inflow to the Aral Sea facilitated deltaic lakes filling. Lake systems functioning dynamics reflects water supply regime: water accumulation is found in autumn-winter period, intensive discharge takes place in warm time, maximum level was fixed in march, minimum – in August-September. Similar phases of level rise and decline are typical for river itself. Extreme drought (1993-

1994) provided active water exchange with channel flow; in result 15% of lake water was replaced by fresh river water that led to positive changes in hydrochemical situation. But during relatively dry years (1995-1996) with loss of Amanotkel structure's command position, deltaic lakes recharge became problematic and maritime system ceased its existence at all [6].

In all 4 zones of delta there are common and different features both of landscape and lakes (wetlands). Common feature is sea level decline down to 37.0-42 m; big level fluctuations in Berg strait; big fluctuations in water supply to delta; low technical state of infrastructure; lack of water regulation and management. In result of this, many lakes are drying up and their area is permanently changing.

Specific questions for separate zones:

Zone "a" – dried area and area under Small sea impact on stable landscape maintaining and new stable landscapes creation. Breach of Kokarak dike has happened in spring 1999 due to construction low quality and project absence: slopes were taken inappropriate for unfixed conditions, dike ground contains high content of fine-grained silty barkhan sands; lack of outlets. In result, area of inundated bed is negligible. Even under water level 42 m, the sea does not help to combat desertification.

Zone around Aralsk city is outside of Small sea impact. Nevertheless, periodically inundated area very quickly is overgrown by wild vegetation (tamarisk, saxaul, salt tolerant plants, trees) even under slight moistening (field expedition in October 2002).

Zone "b" and "c" – maritime systems and delta suffered much because of Aklak and Amanatkol dam breach, order of interactionзоны between lake system and river has been violated.

Before Aklak water-work and Raim dam destruction in spring maximum inundation of lakes occurred; in summer regime was maintained at expense of water coming through canals. Unfortunately, structures with gates of double action were not designed and built and canals are opened and closed by digging machinery or manually.

Zone "d" is characterized by unstable water supply to huge Aksai-Kuandarya lake system. Though its head structure-canal Aksai has capacity of 20 m^3/s, all canal system is out of control.

Dad technical state of uniting canals always aggravates situation. If previously state allocated some money for their reconstruction, presently they are not rehabilitated. Since 1988 many sluices and canals are destroyed by spring ice movement and lake waters. Water supply from river to lake systems is made though building earthen dams and embankments, which are opened and closed not at right time. Canals are overgrown by reed and reed mice, silted and destroyed and their capacity decreases. Water supply is irregular, lakes are drying up.

Often water from lake system returns to Syrdarya due to earthen structures destruction. Repair works on canals and sluices make water supply to lakes more difficult permitting it only under river water level higher than 56,6m. In result, Kamislibas and Akshatau lake systems filling becomes problematic. Water level is lowering, hydrological and hydrochemical situation is aggravating.

Analyzing materials from partners and information obtained during field inspections and meetings with local population, authors come to conclusion that water management in delta is absent. Lake system water availability and management should be resolved in connection with common scheme of water supply, creation of infrastructure for water supply to Small sea regulation. Without deep analysis of current processes it is impossible to make long-term forecast of situation development.

IV. STATE-OF-ART OF LAKE SYSTEMS AND WATER BODIES ACCORDING TO RS AND GIS DATA

Lake systems and water bodies dynamics was determined on topographic maps and RS data (satellite images of 1999…2003). Obtained results in GIS were compared with initial data –topographic maps- before sea drying up, statistical data from various design and ecological situation.

Works were performed in several stages:

1. During the first stage preliminary assessment of Small sea and deltaic lakes water surface has been done. Sources of information were as follows:

- Topographic maps of scale 1:500 000, 1: 200 000, 1: 700 000;
- Thematic maps of scale 400 000, 1: 300 000;
- Satellite images for 2000 and 2002.

As result, thematic information layers in real coordinates were built: rivers, large canals, lakes, Aral Sea (northern part). Main source of information – topographic maps of scale 1: 200 000 reflecting state of locality by 1982.

2. During the second stage main task was preparation of project materials' electronic version (dams, hydrostructures, etc.). Map "Restoring the conveyance canal system of the delta was one of information sources for GIS processing. As result, thematic information layers in real coordinates were built: rivers, hydrostructures, large canals, lakes.

3. During the third stage field work (done by I.Ruziev) results were introduced in GIS.

In result of works fulfilled thematic information layers created during previous stages were corrected. Besides, executor has built a map where field expedition route were presented (fig. 4.1). Existing and designed dams on Syrdarya river (acc. to I.Ruziev's scheme) coverage has been established.

4. To define lakes dynamics, satellite images were digitized for following time:

- August 1999
- October 1999
- July 2000
- March 2003.

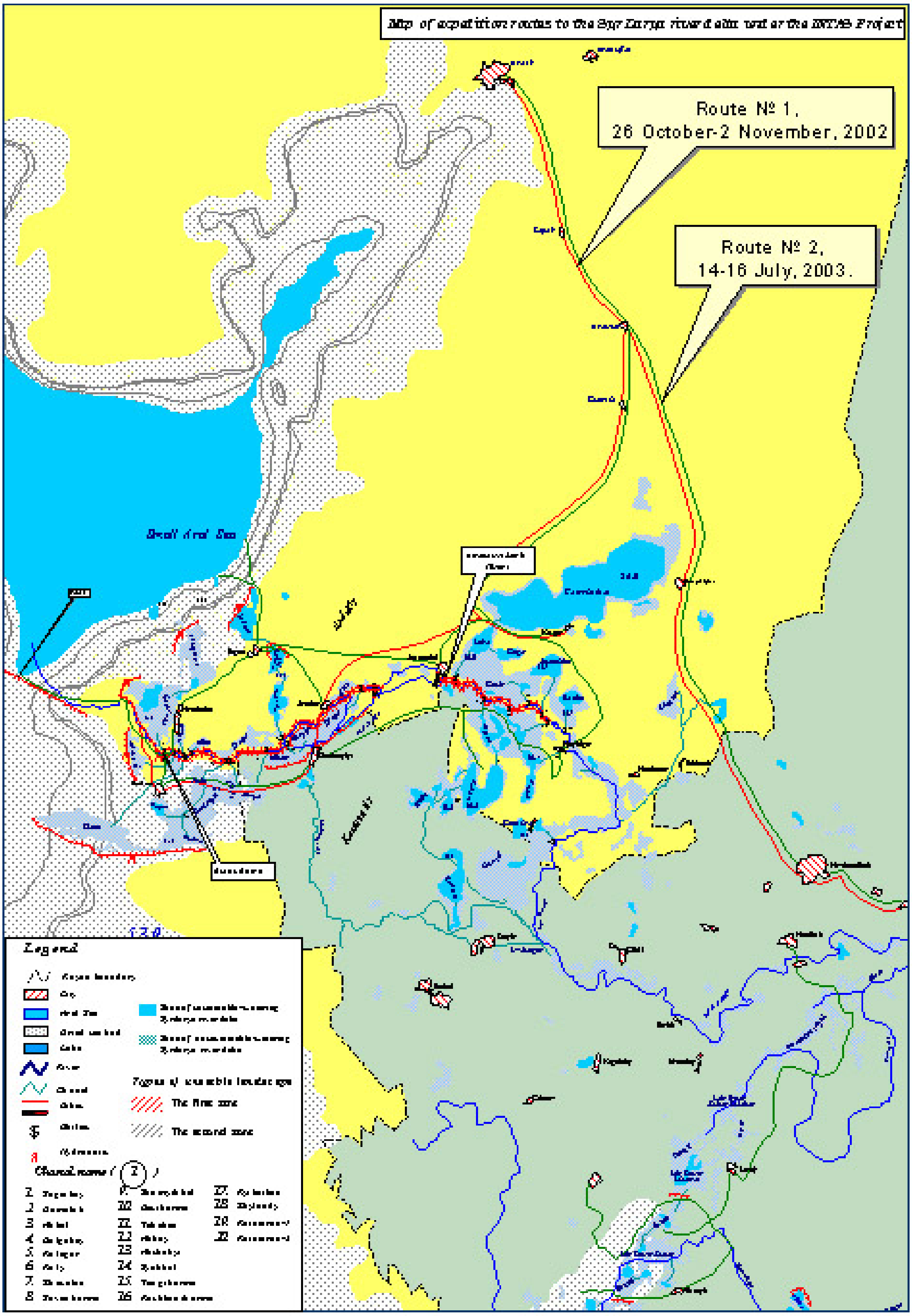


Fig 4.1

Satellite images digitizing showed that open water surface and wetland area vary significantly. To demonstrate these phenomena two images are presented:

Satellite by 10.1999 Satellite by 03.2003

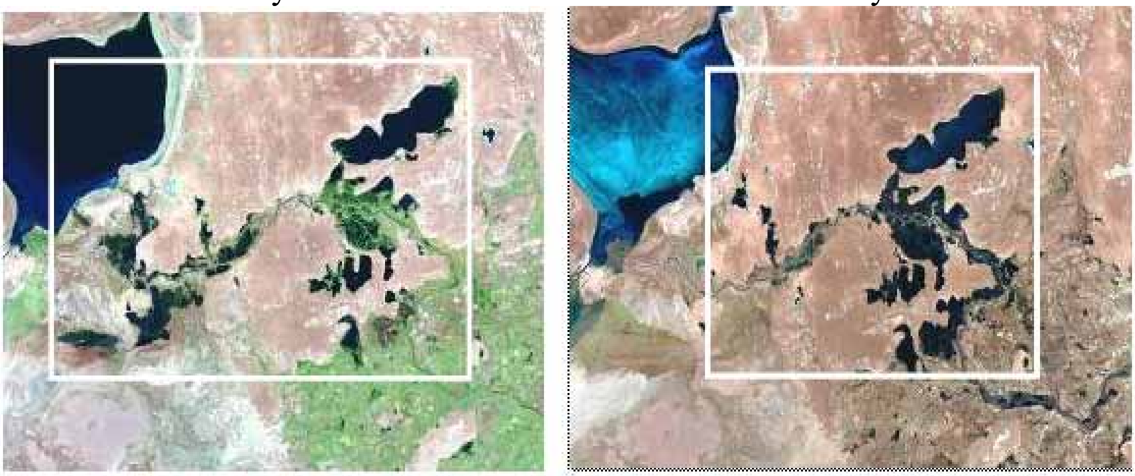


Fig. 4.2

Results of satellite images digitizing are shown in table 4.1. Thematic layer “Unstable areas of watering” has been made on base of digitizing results; polygons having biggest area are collected in this layer.

On each stage and source of information (except topographic maps because transformation in real coordinate system is not included) including satellite images following operations were performed:

1. Digitizing
2. Transformation into real coordinate system
3. Topology creation
4. Attributive information introduction

Analysis of compared water bodies (table 4. 1) shows that:

- Water bodies area varies recent years depending on total inflow to delta within 39.6-104.8 th.ha;
- Under sustainable water supply area of deltaic lakes and wetlands can approach to initial one (159.75 th.ha in 1960).

On base of this comparison necessary water supply is determined with following initial data:

- evaporation from total surface – 9000 m^3/ha;
- evaporation from reed – 15000 m^3/ha;
- surface under reed is 25% of lake area;
- evaporation from wetlands – 6500 m^3/ha;
- running – 30%;
- system efficiency -0,75

Table 4.1. Dynamics of lakes and wetlands area changes, th. ha

	Delta and lakes	Acc. to satellite images, lakes				lakes	wetlands	lakes	wetlands	lakes	wetlands	lakes	wetlands
		1967	1981	1989	1997	Aug. 99	Oct. 99	Oct. 99	July. 00	July. 00	March. 03	March 03	max
1	Coastal zone	-	-	-	-	-	-	-	-	-	-	-	3.29
2	Maritime delta												
2.1	Maritime right bank	14.71	6.12	1.4	7.1	0.96	9.4	5.56	5.73	3.53	6.58	2.74	9.4
2.2	Maritime left bank	9.61	4.67	0.55	4.43	0.00	14.23	8.37	2.14	0.77	4.62	1.26	14.23
	Total Maritime delta	24.32	10.79	1.95	11.53	0.96	23.63	13.93	7.87	4.29	11.20	4.01	23.63
3.0	Middle delta												
3.1	Kamislibas	26.7	20.10	17.70	21.45	19.18	22.59	16.99	28.16	16.42	34.21	23.26	34.21
3.2	Akshatau	19.8	12.7	68.00	9.97	8.41	15.50	8.27	15.42	8.21	37.42	24.65	37.42
	Total middle delta	46.5	32.80	85.70	31.42	27.59	38.09	25.26	43.58	24.64	71.63	47.91	71.63
4	Aksai-Kuvandarya zone	37.3	29.40	8.70	12.7	11.30	27.35	12.22	21.28	9.13	64.49	43.87	64.49
	Grand Total	108.12	72.99	96.35	55.65	39.85	89.07	51.41	72.73	38.06	147.32	95.79	159.75

Calculation results are presented in table 4.2 below.

Table 4.2. Calculation of necessary volume of water for lakes and wetlands watering in Syrdarya delta

Parts and systems	Area, th.ha		Total water requirements, mln.m^3 /yr					
	lakes	wetlands	Evaporation from lakes	Evaporation from reed	Evaporation from wetlands	Running	Filling	Total
Coastal		3,29			19,74	6,42 (21,39)		27,81
Maritime	13,93	9,7	125,37	8,9	58,62	57,9 (192,89)	408,6	257,8
Left bank	8,37	5,86	75,3	5,0	35,16	34,62 (115,46)		188,35
Right bank	5,56	3,84	50.04	3,9	23,0	23,1 (76,94)		124,66
Middle delta	47.91	23,72	431.2	28,1	142,32	180,4 (601,62)	11954	782,1
Kamislibash	23.26	10,95	209.34	14,49	65,7	86,9 (289,53)		484,91
Akshatau	24.65	12,77	221.85	13,2	76,62	93,5 (311,67)		517,78
Aksai-Kuvandarya	43.87	20,62	395.0	26,0	123,2	163,3(544,2)	898	707,46
Total for systems	105.7	57,33	951.57	60,0	346,0	408,1(1370) 1690,0	2502	1747,36
Total with account of running and efficiency								2329,81
Need for dry year								1300
Need for average year								1690
Need for wet year								2700

V. DYNAMICS OF SOIL COVER AND LANDSCAPE STATE-OF-ART IN NORTHERN PREARALIE

Analysis and assessment of soil cover were performed by National Ecological Society of Kazakhstan (NES) on base of thematic maps, grey literature and publications. Results of analysis were used for description of processes within dried seabed. Mrs.Budnikova has prepared map of landscapes for Aral Sea died bed.

Following works were performed:

- Digitizing and calculation of areas on base of map of 1958 (fig. 5.1) (Aral Sea level –53 m);
- Digitizing and calculation of areas on base of map of 1992 (fig. 5.2) (Aral Sea shrinking);

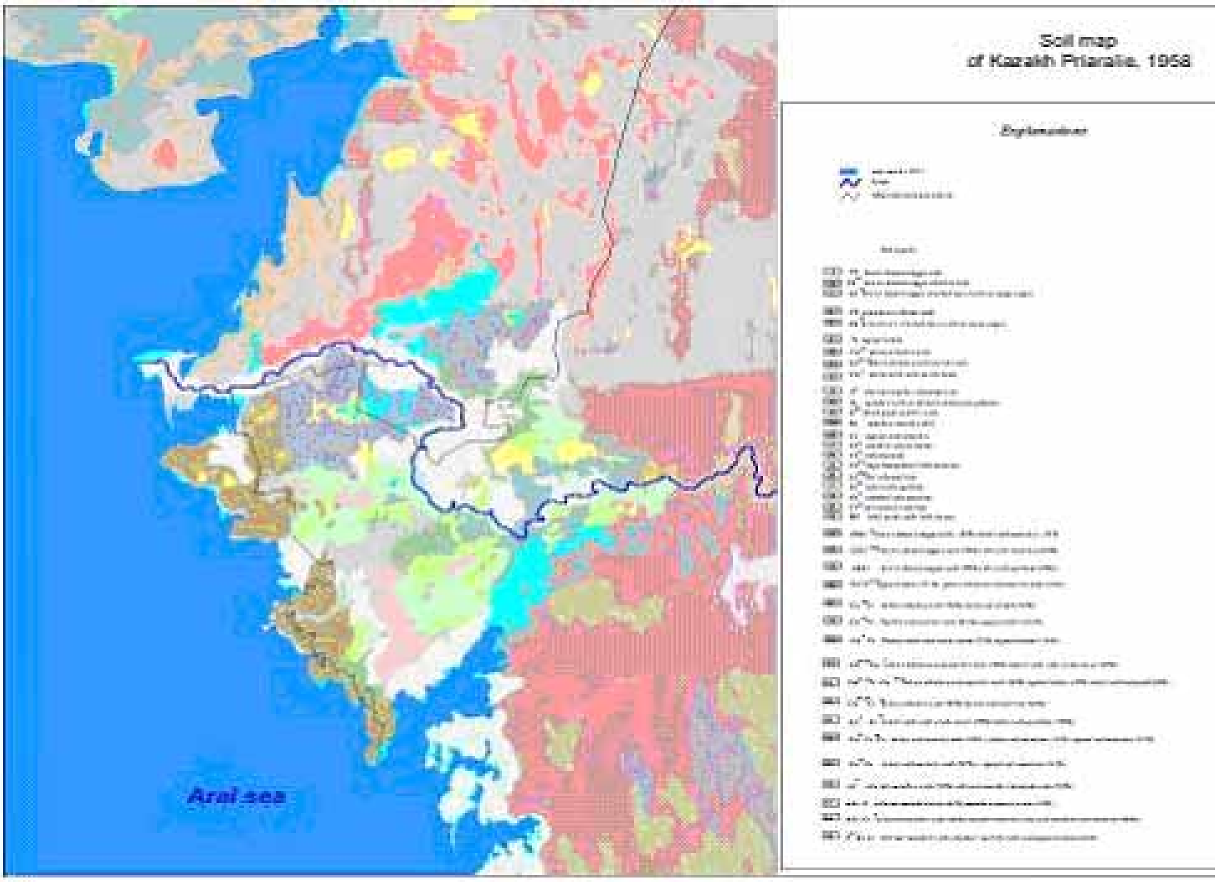


Fig. 5.1

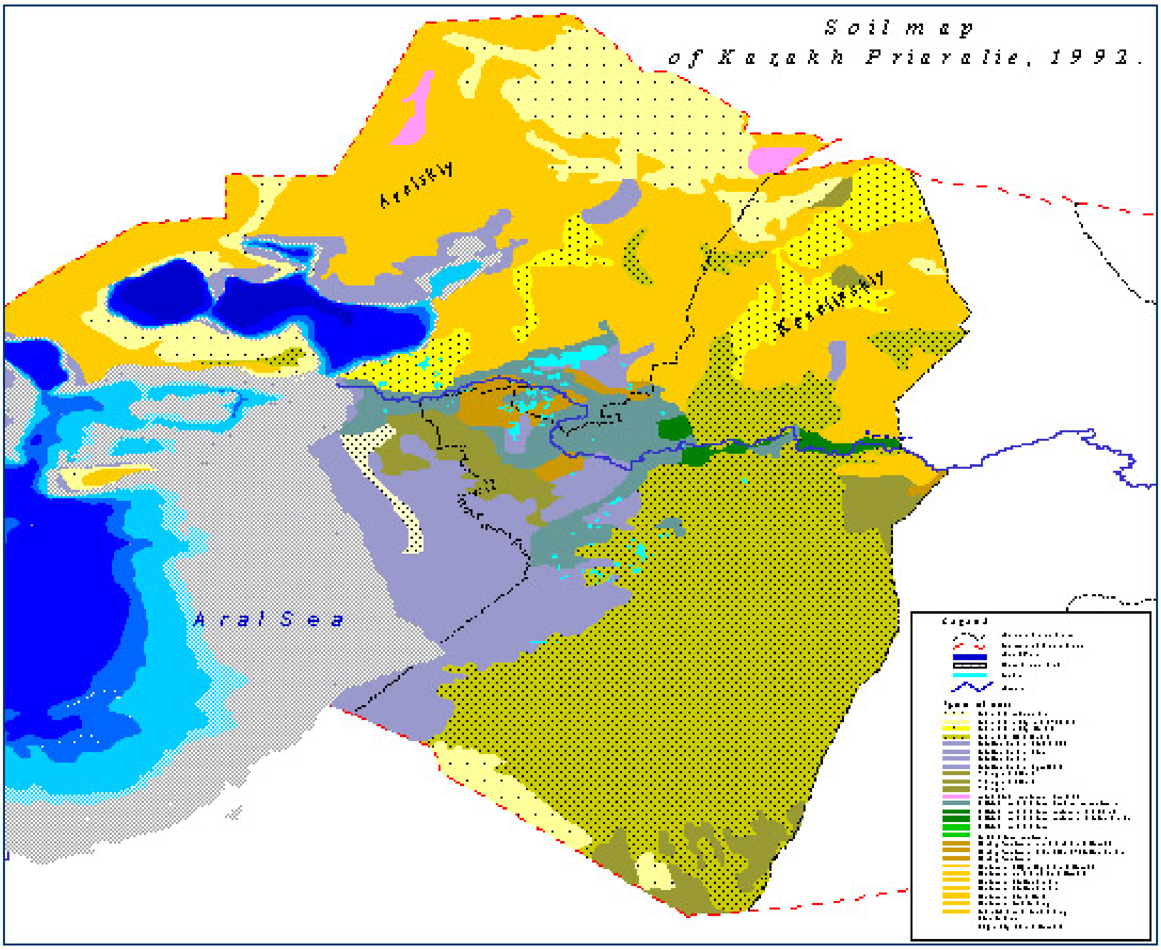


Fig. 5.2

GIS processing was carried out in tow rayons of Kyzyl-Orda oblast: Aral and Kazalinsk. Aralsk rayon area according to WARMIS (1995) amounts for 5513,7 th.ha, Kazalinsl rayon –4008,2 th.ha, total area is 9521,9 тыс. Га. According to GIS data (1995) Aralsk rayon area amounts for 54172,7 th.ha, Kazalinsl rayon –3996.8 th.ha, total area is 9468,98 th.ha.

Results of processing (digitizing, transformation into real coordinate system, input attributive information) of thematic soil maps are presented in table 5.1.1. Total area of Aralsk rayon consists of soil species and part of Aral Sea. By 1958 sea area within Aralsk rayon amounted for 3244,6 th.ha and total area amounted for 9182,9 th.ha. Thematic soil map by 1958 does notcover south part of Kazalinsk rayon. On map of 1992 sea area is 1999,7 th.ha and total area in two rayons is 9431,0 th.ha.

It worth to note that results of calculation made using GIS on base of soil maps and presented in Table 5.1.1 coincide with actual administrative area with discrepancy of 5-10%.

NES data presented in Table 5.1.2 are based on collection “List of land users in Kazakh SSR”, 1990. These results differ from soil maps (1958-1992) GIS processing data. Discrepancies are attributed to fact that long-term used land are not included in administrative rayon area.

These lands were given for certain time to various rayons for provisional use.

Table 5.1.1
Area calculated based on maps of 1958 and 1992, th.ha

	Soil name	1958	1992
I	Brown ordinary	2023,0176	1434,6251
	Brown desert-steppe	106,9066	
	Brown salt		139,7876
	Brown salt		288,9393
	Brown undeveloped		
	Brown low developed		7,0849
	Brown deflated		
	Total I	2129,924	1870,437
II	Grey-brown	14,2587	70,3188
	Grey-brown alkali-salonchak		
	Grey-brown undeveloped	62,9243	
	Total II	77,183	70,3188
III	Takir typical	65,5693	
	Takiry with sandy cover	63,1462	
	Takiry		92,586
	Takiry saline	242,763	305,8333
	Takir saline		9,0297
	Total III	371,4785	407,449
IV	Alkali salt brown crusty		
	Alkali salt brown shallow		58,7648
	Flood-meadow brown salt		33,1804
	Total IV	0	91,9452
V	Alkali marshy takiry soil	14,411	
	Alkali typical	16,4384	327,5654
	Alkali meadow	0,8948	117,1527
	Alkali sory	96,1209	113,9022
	Alkali maritime		877,0225
	Total V	127,8651	1435,643
VI –a	Sands flat fixed	43,7832	2066,0658
	Sands hilly fixed	82,3278	283,5095
	Total sands fixed	126,111	2349,5753
VI –b	Sands hilly half-fixed	1753,7081	803,3465
VI –c	Sands barkhan		36,2517
VI –d	Sands maritime		
	Total VI	1879,819	3189,174
VII	Alluvial-meadow	365,8721	
	Alluvial-meadow deserted	23,466	
	Meadow of tertiary-cretaceous plateau	4,8665	
	Total VII	394,2046	0

	Soil name	1958	1992
VIII	Flood-marshy	133,1815	
	Meadow-marshy	47,7954	
	Flood-meadow brown deserted		8,6361
	Flood-meadow marshy brown		262,2172
	Flood-marshy brown turf		34,9651
	Flood-marshy turf		1,6766
	Total VIII	180,9769	307,495
	Grand Total I-VIII	5161,451	7372,461

Table 5.1.2
Land resources dynamics in Kazakh Prearalie, th. ha

		Kazalinsk rayon			Aralsk rayon				Total		
	Type of soil	1960	1980	1994	1960	1980	1995	2000	1960	1980	1995
I	Brown ordinary soil	999,8	798,1	762,9	1334,6	1275,7	1201,2		2334,4	2073,8	1964,1
	Brown saline soil	157,1	114,6	114,2	956,3	858,1	833,8		1113,4	972,7	948
	Brown soil with crush stones	61,8	56,4	52,1	426,7	325,7	305,7		488,5	382,1	357,8
	Brown soil primitive (drying)	0	0	0	0	0	24,5	24,5	0	0	24,5
	Total I	1218,7	969,1	929,2	2717,6	2459,5	2365,2	24,5	3936,3	3428,6	3294,4
II	Grey-brown soil ordinary	57,9	54	54	139,6	122,3	97,3		197,5	176,3	151,3
	Grey-brown saline soil	143,5	143,5	143,5	148,8	162,3	136,8		292,3	305,8	280,3
	Grey-brown soil with crush stones	65,4	65,4	65,4	35,5	32,5	30,2		100,9	97,9	95,6
	Grey-brown soil primitive (drying)	0	0	0	0	0	1,5	1,5	0	0	1,5
	Total II	266,8	262,9	262,9	323,9	317,1	265,8	1,5	590,7	580	528,7
III	Takir typical	84,4	84,4	84,4	48,6	48,6	48,6		133	133	133
	Takity soil	57,7	58,4	58,9	44,1	45,2	46,9		101,8	103,6	105,8
	Takity soil (drying)	0	0	0	0	0,9	1,6	1,6	0	0,9	1,6
	Takity soil old irrigated	26	26	20	0	0	0		26	26	20
	Total III	168,1	168,8	163,3	92,7	94,7	97,1	1,6	260,8	263,5	260,4
IV	Alkali desert brown	25	25	25	213,6	213,6	210,6		238,6	238,6	235,6
	Alkali meadow brown	5	5	5	24,8	24,8	23,7		29,8	29,8	28,7
	Total IV	30	30	30	238,4	238,4	234,3	0	268,4	268,4	264,3
V	Alkali typical	56,9	57,5	60,3	60,7	68,9	73,3	0	117,6	126,4	133,6
	Alkali typical sory	55,1	55,2	45,1	88,6	88,6	88,6	0	143,7	143,8	133,7
	Alkali residual	1,6	1,6	1,6	11,3	11,3	11,3	0	12,9	12,9	12,9

	Type of soil	Kazalinsk rayon 1960	Kazalinsk rayon 1980	Kazalinsk rayon 1994	Aralsk rayon 1960	Aralsk rayon 1980	Aralsk rayon 1995	Aralsk rayon 2000	Total 1960	Total 1980	Total 1995
	Alkali marshy	0	0	0	0	104,6	115,7	249	0	104,6	115,7
	Total alkali residual and marshy	1,6	1,6	1,6	11,3	115,9	127	249	12,9	117,5	128,6
	Alkali maritime (drying)	0	0	0	0	272,41	393,1	504	0	453,1	938,3
						180,7	545,2	300	0	180,7	545,2
	Alkali of impulversation	0	0	0	34,2	34,2	34,2		34,2	34,2	34,2
	Alkali meadow irrigated	12,8	15,3	22,4	0,5	1,2	1,7		13,3	16,5	24,1
	Total V	126,4	129,6	129,4	161,1	547,0	683,7	753	287,5	676,6	813,1
VI-a	Sands hilly fixed	1550,6	1465,6	1662	1764,2	1757,3	1621,9		3314,8	3222,9	3283,9
VI-a	Sands hilly fixed	522,3	456,8	558,1	517,7	537,1	527,6		1040	993,9	1085,7
VI-b	Sands hilly half-fixed (drying)	0	0	0	0	9,8	55,6	68	0	9,8	55,6
									0	0	0
VI-c	Sands hilly (drying)	0	0	0	0	92	129	150	0	92	129
VI-d	Sands maritime (drying)	0	0	0	0	253,6	854,9	1082,4	0	253,6	854,9
	Total VI	2072,9	1922,4	2220,1	2281,9	2649,8	3189	1300,4	4354,8	4572,2	5409,1
VII	Alluvial-meadow	73,4	42	66,3	6,9	41,6	57,5		80,3	83,6	123,8
	Alluvial-meadow tugai	6,9	2,4	0,135	5,1	0	0,1		12	2,4	0,235
	Alluvial-meadow deserted	6,9	14,8	12,4	0,1	15	36,3		7	29,8	48,7
									0	0	0
	Alluvial-meadow irrigated	0	45,8	43,1	0	0	0		0	45,8	43,1
	Total VII	87,2	105	121,935	12,1	56,6	93,9	0	99,3	161,6	215,835
VIII-a	Meadow-marshy	52,1	44,2	34,6	3,6	42,8	36,8		55,7	87	71,4
	Meadow-marshy deserted	5,9	11,4	7,6	0	10,6	8,7		5,9	22	16,3
	Meadow-marshy irrigated	0	19,3	19,3	0	0	0		0	19,3	19,3
VIII-b	Marshy	27,9	14,4	4,7	0	46,6	15,6		27,9	61	20,3

		Kazalinsk rayon			Aralsk rayon				Total		
	Type of soil	1960	1980	1994	1960	1980	1995	2000	1960	1980	1995
	Marshy-plavni	40,7	0	0	147,3	0	0		188	0	0
	Rice-marshy	0	19,5	17,1	0	0	0		0	19,5	17,1
VIII	Total VIII	126,6	108,8	83,3	150,9	100	61,1	0	277,5	208,8	144,4
	Grand Total I-VIII	4096,7	3696,6	3940,14	5978,6	6463,1	6690,1	2381	10075,3	10159,7	10929,9

Analysis of landscape map within sea dried bed prepared on base of satellite images (summer 2000) allowed receive quantitative and qualitative information about natural complexes developing in continental conditions.

Electronic version of this map (digitizing, transformation into real coordinate system, input attributive information) allowed calculate landscape area over its type (Fig. 5.3).

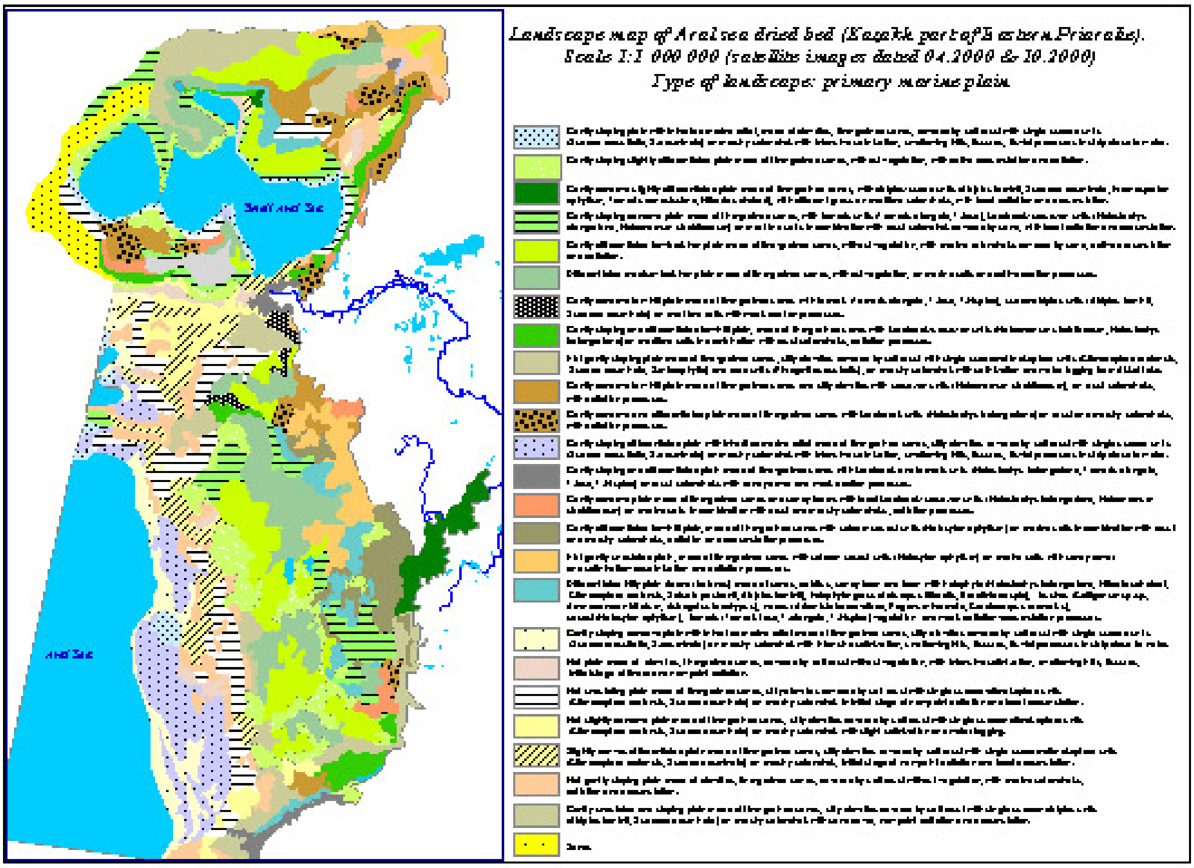


Fig.5.3

Table 5.2
Characteristic of natural complexes within dried seabed, ha

Landscape name and description	Area, ha
1. Gently sloping plain with inherited marine relief, made of alevrites, fine-grained sands, covered by salt crust with single suaeda units (*Suaeda crassifolia, S.acuminata*) on marshy solonchak with intensive salinization, swallowing hills, fissures, fluvial processes in strip close to water.	38175,0
2. Gently sloping differentiated plain with inherited marine relief made of fine-grained sands, silty alevrites covered by salt crust with single suaeda units (*Suaeda crassifolia, S.acuminata*) on marshy solonchak with intensive salinization, swallowing hills, fissures, fluvial processes in strip close to water.	182284,6

Landscape name and description	Area, ha
3. Gently sloping concave plain with inherited marine relief made of fine-grained sands, silty alevrites covered by salt crust with single suaeda units (*Suaeda crassifolia, S.acuminata*) on marshy solonchak with intensive salinization, swallowing hills, fissures, fluvial processes in strip close to water.	107550,7
4. Flat plain made of alevrites, fine-grained sands, covered by salt crust without vegetation, with intensive salinization, swallowing hills, fissures, initial stage of linear and non-point deflation.	38140,9
5. Flat undulating plain made of fine-grained sands, silty alevrites covered by salt crust with single suaeda-climakoptera units (*Climacoptera aralensis, Suaeda acuminata*) on marshy solonchak in initial stage of non-point deflation and local accumulation.	163072,3
6. Flat slightly concave plain made of fine-grained sands, silty alevrites covered by salt crust with single suaeda-climakoptera units (*Climacoptera aralensis, Suaeda acuminata*) on marshy solonchak with slight salinization and water logging.	67850,6
7. Slightly convex differentiated plain made of fine-grained sands, silty alevrites covered by salt crust with single suaeda-climakoptera units (*Climacoptera aralensis, Suaeda acuminata*) on marshy solonchak, initial stage of non-point deflation and local accumulation.	121654,1
8. Flat gently sloping plain made of alevrites, fine-grained sands, covered by salt crust without vegetation, with marine solonchaks, deflation and accumulation.	129437,9
9. Gently undulated and sloping plain made of fine-grained sands, silty alevrites covered by salt crust with single suaeda-atriplex units (*Atriplex fominii, Suaeada acuminata*) on marshy solonchak with sand cover, non-point deflation and accumulation.	70294,1
10. Gently sloping slightly differentiated plain made of fine-grained sands, without vegetation, with active accumulation and deflation.	158592,5
11. Gently concave slightly differentiated plain made of fine-grained sands, with atriplex-sueda units (*Atriplex fominii, Suaeada acuminata, Eremosparton aphyllum, Tamarix ramosissima, Nitraria schoberi)*, with different grass on maritime solonchaks, with local deflation and accumulation.	51381,5
12. Gently sloping concave plain made of fine-grained sands, with tamarix units (*Tamarix elongata, T.laxa),* karabarak-sarsazan units *(Halostachys belangeriana, Halocnemum strobilaceum)* on maritime soils in combination with crust solonchak covered by sand, with local deflation and accumulation.	131511,7
13. Gently differentiated low-barkhan plain made of fine-grained sands, without vegetation, with marine solonchaks covered by sand, active accumulation and deflation.	160847,9
14. Differentiated medium-barkhan plain made of fine-grained sands, without vegetation, on marine soils and active _reland processes.	179224,1
15. Gently concave low-hill plain made of fine-grained sands with tamarix (*Tamarix elongata, T.laxa, T.hispida), sueda-atriplex units* (*Atriplex fominii, Suaeada acuminata*) on maritime soils with weak _reland processes.	17054,1
16. Gently sloping and differentiated low-hill plain, made of fine-grained sands with karabarak-sarsazan units *(Halocnemum strobilaceum, Halostachys belangeriana)* on maritime soils in combination with crust solonchaks, deflation processes.	63369,3
17. Flat gently sloping plain made of fine-grained sands, silty alevrites covered by salt crust with single suaeda-climakoptera units (*Climacoptera aralensis, Suaeda acuminate, S.microphylla*) and reed units (*Phragmites australis)*, on marshy solonchak with salinization and water logging from Akkol lake.	51292,6
18. Gently concave low-hill plain made of fine-grained sands and silty alevrites with sarsazan units (*Halocnemum strobilaceum*), on crust solonchaks, with deflation processes.	78627,6
19. Gently concave and differentiated plain made of fine-grained sands with karabarak units (*Halostachys belangeriana*) on crust and marshy solonchaks, with deflation processes	48390,5

Landscape name and description	Area, ha
20. Gently sloping and differentiated plain made of fine-grained sands with karabarak and tamarix units (*Halostachys belangeriana, Tamarix elongata, T.laxa, T.hispida*) on crust solonchaks with sandy cover and weak _reland processes.	30018,9
21. Gently concave plain made of fine-grained sands and sandy loams with local karabarak-sarsazan units (*Halostachys belangeriana, Halocnemum strobilaceum)* on marine soils in combination with crust and marshy solonchaks, deflation processes.	36895,9
22. Gently differentiated low-hill plain, made of fine-grained sands with seldom saxaul units (*Haloxylon aphyllum*) on marine soils in combination with crust and marshy solonchaks, deflation and accumulation processes.	80924,3
23. Flat gently undulated plain, made of fine-grained sands with seldom saxaul units (*Haloxylon aphyllum*) on marine soils with sandy cover *and salinization-desalinization and deflation processes..*	70210,5
24. Differentiated hilly plain (former _relands) made of sands, detritus, sandy loam and loam with halophyte (*Halostachys belangeriana, Nitraria schoberi, Climacoptera aralensis, Salsola paulsenii, Atriplex fominii)*, halophyte-grass (*Aeluropus littoralis, Karelinia caspia),* bushes (*Calligonum* sp.sp., *Ammodendron bifolium, Astragalus brachypus)*, weeds (*Artemisia terrae-albae, Peganum harmala, Ceratocarpus arenarius*), saxaul *(Haloxylon aphyllum),* tamarix *(Tamarix laxa, T.elongata, T.hispida)* vegetation and weak deflation-accumulation processes.	59520,2

Similarly to project INTAS RFBP-1759 and NATO SFP- 434757 we divide all landscapes into: stable, overgrown, overgrowing and unstable. Assessment is made of unstable landscape coverage within Small Aral Sea aquatic area depending on designed dam construction altitude (Fig. 5.4).

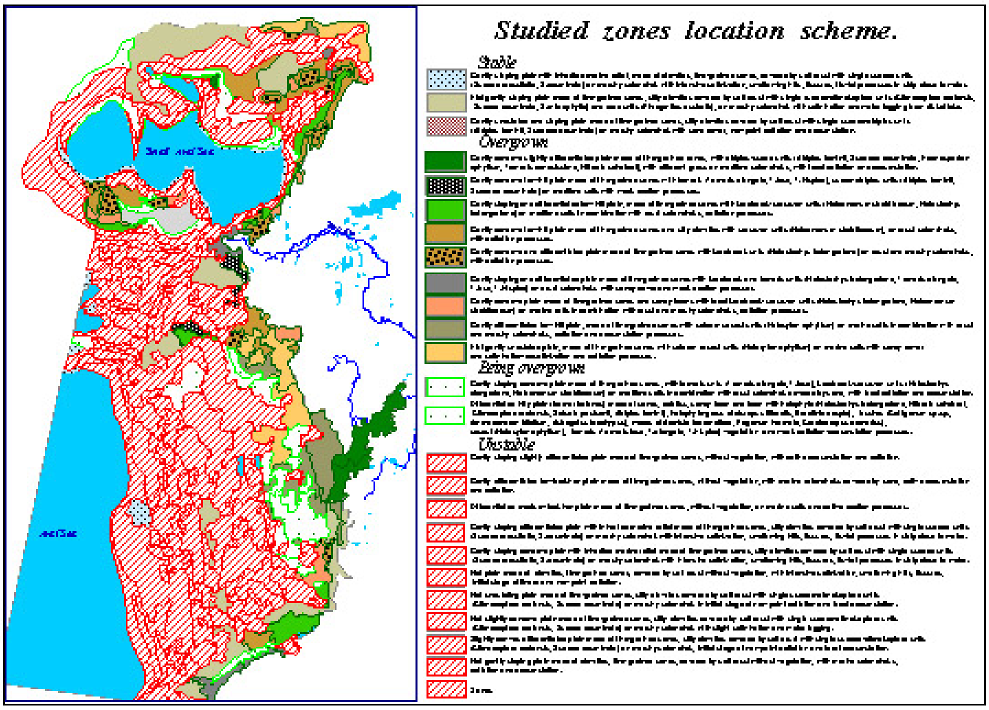


Fig.5.4

GIS processing has being performed as follow. At the first stage area of all listed landscapes by 2000 has been defined (table 3.3). At the following stages assessment of existing landscapes under sea level change from 42 to 48 m (table 5.4) has been made.

On map "Comparison of unstable landscapes in Syrdarya delta" two categories of unstable landscapes are apportioned: 1st category is defined on base of landscape map by 2000 (red color on fig. 5.4) and 2nd category (grey color on map) on base of soil map by 1992. Second category is presented by sandy and barkhan soils with area of **183782.42 ha.**

Table 5.3
Areas calculated on base of landscape map by 2000 for all Kazakh Prearalie, ha

Landscape	stable	unstable	ranked	ranking
Present state-of-art*	265303,2	1585325,8	549058,2	237034,9
42 altitude of structure	257722,2	1552946,8	547971,3	224581,3
48 altitude of structure.***	251681,8	1499677,7	940550,3	204181,5

*) 2000

**)Small sea filling up to altitude of 42 m

***) Small sea filling up to altitude of 48 m

Data in table 5.3 show that Northern (Small) sea level increase does not impact landscape transformation within dried seabed in Eastern part of the Aral Sea. Because of that, detail assessment of landscape change within Small sea dried bed under level increase from 42 to 48m has been made. Data are presented in table 5.4.

Table 5.4
Areas calculated on base of landscape map by 2000, ha

Small sea						
Landscape	Sea water surface	Area of additional watering altitude****	stable	unstable	overgrown	overgrowing
Present state-of-art*	249840		123658,3	368406,4	209073,8	87389,2
42 altitude of structure	310550	60710	116932,8	337250,8	208014,4	74799,9
48 altitude of structure.***	456290	206450	101438,1	285150,8	145942,1	54530,6
Recharge at altitude 49,50			98603,1	269588,5	123731,2	47452,6

****)Area of additional watering at altitude 42 and 48 m

Area of all types of landscapes within dried Small sea bed amounts for 788527.7 ha; under Small sea level change from 42 to 48 m area will amount for 736997.9 and 587061.6 ha, respectfully.

Under Small sea level change area of unstable landscapes will decrease by 31155.6 ha at 42 m and by 83255.6 ha at 48 m because under altitude 48 m there is recharge from ground water and part of unstable landscapes will be transformed in overgrowing and their area will reduce by 98817, 9 ha compared with modern state.

Besides, in case of planned hydraulic structures design and construction, area of unstable watering, earlier defined as 2nd category of unstable landscapes, will be partially covered with water and its area will amount for 119742.79 ha.

VI. DAMAGE IN KAZAKH PREARALIE AND ITS DISTRIBUTION OVER ZONES

6.1. Damage distribution over zones

In Kazakh Prearalie 4 zones are distiguished: coastal part, maritime lake system, middle delta, Aksai-Kuvandarya delta and upper delta. First three zones relate to Aralsk rayon, upper delta – to Kazalinsk rayon.

It worthy to note, that in coastal part and upper delta there was no any economic activity. That's why, damage distribution in Aralsk rayon will be divided into two parts. Due to lack of information about irrigated area in Aralsk rayon, damage distribution will be performed depending on number of population.

Table 6.1.1
Population number in Aralsk rayon, th. people

	Total	City
Aralsk rayon	68,5	43,4
Aralsk city	31,1	31,1
Zhaksililish village (former Aralsulfat)	7,6	7,6
Saksaulsky village	8,4	8,4

Table 6.1.2
Irrigated area dynamics, th. ha

Year	Aralsk rayon		Kazalinsk rayon		Kazakh Prearalie	
	Availabil-ity	Utilized	Availabil-ity	Utilized	Availabil-ity	Utilized
1960	1	0,5	15,4	13,3	16,4	13,8
1965	1	0,5	14,6	13,5	15,6	14
1970	1	0	15,9	14,3	16,9	14,3
1975	1,3	0	18,8	18,8	20,1	18,8
1980	2,1	0	33,5	30,2	35,6	30,2
1985	2,7	0,1	34,1	32,4	36,8	32,5
1990	3,1	3	34,5	32	37,6	35
1991	3,1	2,2	34,5	32,1	37,6	34,3
1992	3,1	2,5	34,5	33,5	37,6	36
1993	3,1	1,5	34,5	32,4	37,6	33,9
1994	3,1	1,2	34,5	25,6	37,6	26,8
1995	3,1	0,8	34,5	27,1	37,6	27,9
1996	3,1	0,8	34,5	21,1	37,6	21,9
1997	3,1	0,8	34,5	16,5	37,6	17,3
1998	2,6	0,8	34,5	14,3	37,1	15,1
1999	2,6	0,8	33,2	13,6	35,8	14,4
2000	1,2	0,8	33,2	12,8	34,4	13,6
2001	1,2	0,7	33,2	12,8	34,4	16

Table 6.1.3
Dynamics of agricultural lands structure change in Kazakh Prearalie, th.ha (Aralsk rayon)

Years	Irrigated area	Hey fields *	Fallow lands	Pastures**	Total
1960	0,3	59,1 / 39,9	2,1	1336,2 / 524,8	1397,7
1965	0,3	58,2 / 28,4	2,4	1771,9 / 599,6	1832,8
1970	0,4	49,1 / 25,9	0,1	1783,1 / 783,1	1832,7
1975	0,4	48,4 / 10,4	0,1	1994,3 / 1102,8	2043,2
1980	0,4	40,6 / 3,2	0,3	1977,3 / 1385,1	2018,6
1985	0,3	8,4 / 2,6	0,2	1877,4 / 1401,4	1886,6
1990	0,5	8,4 / 2,8	2,9	1877,4 / 1290,8	1889,2
1991	0,3	8,5 / 3,4	2,8	1944,2 / 1220,5	1955,8
1992	0,4	9,4 / 3,8	2,5	2045,6 / 1259	2057,9
1993	0,5	9,4 / 4,2	2,4	2114,6 / 1259	2126,9
1994	0,4	9,4 / 4,6	2,2	2125,6 / 1260,5	2137,6
1995	0,3	9,5 / 4,5	2,1	2154,9 / 1260	2166,8
1996	0,5	9,4 / 4,2	2,5	2198, 6 / 1258,8	2211
1997	0,7	9,4 / 4,3	2,8	2201,5 / 1260,8	2214,4
1998	0,8	9,5 / 4,1	2,9	2215,3 / 1260,8	2228,6
1999	0,7	8,4 / 3,7	2,6	2215,3 / 1241,5	2227
2000	0,7	7,2 / 3,2	2,9	2212,5 / 1209,6	2223,3
2001	0,7	6,3 / 3	2,7	2210,4 / 1194,4	2220,1

* Numerator – hey fields area, total; denominator –reed area;
** Numerator – pastures area, total; denominator – area of watered pastures.

Table 6.1.4
Dynamics of agricultural lands structure change in Kazakh Prearalie, th.ha (Kazalinsk rayon)

Years	Irrigated area	Hey fields *	Fallow lands	Pastures**	Total
1960	2,8	92,3 / 43,5	3,7	2735,7/ 799,3	2834,5
1965	10,1	80,3 / 36,7	25,8	2740/ 1337	2856,2
1970	14,3	78,7 / 37,2	16,0	2760 / 1734,4	2869
1975	18,8	77,3 / 28,9	10,8	2823,6/2361,5	2930,5
1980	30,2	34,7 / 14,1	8,0	2817,3/2462,4	2890,2
1985	32,5	29,4 / 12,4	7,0	2816,2 / 2574	2885,1
1990	32,1	28,9 / 10,5	4,1	542,7/1509,4	1607,8
1991	32,0	28,4 / 10.9	3,5	512,1/1424,2	1576
1992	34,5	28,2 / 11,4	3,8	498,6/1384,6	1565,1
1993	32,3	27,8 / 11,8	2,9	478,2/1388,2	1541,2
1994	25,6	27,6 / 12,5	2,4	455,6/1389,2	1511,2
1995	27,0	27,5 /12,9	1,7	433,4/1389,1	1489,6
1996	21,1	27,1 / 12,7	2,1	421,8/1396,9	1472,1
1997	16,5	27,4 / 13,1	8,5	528,9/1396,9	1581,3
1998	14,3	28,0 / 13,8	17,9	596,4/1396,9	1656,6
1999	13,6	28,1 / 13,6	18,2	597,4/1305,7	1657,3
2000	12,8	27,9 / 13,7	19,1	595,8/1269,7	1655,6
2001	16,0	27,6 / 13,4	18,9	599,7/1272,4	1662,2

* Numerator – hey fields area, total; denominator –reed area;
** Numerator – pastures area, total; denominator – area of watered pastures.

Average annual damage from arable lands reduction in Aralsk rayon amounts for $7,3 mln: maritime lake system – $2,8 mln, middle delta - $4,5 mln, total - $162,2mln; in kazalinsk rayon - $5,7mln. Or for total period - $120,8 mln.

Damage from crop yield decline:

Rice – Aralsk rayon average annual damage will be $12 th; maritime delta – $4,6 th, middle delta - $7,4 th, Kazalinsk rayon –$ 168 th.

Maize for grain – Aralsk rayon: average annual damage will be $2,4 th: maritime lake system –$0,9 th, middle delta- $1,5 th, Kazalinsk rayon –$2,1 th.

Potato - Aralsk rayon average annual damage will be $60 th: maritime lake system – $23.11 th, middle delta- $36.9 th, Kazalinsk rayon – $90 th.

Total annual damage: Aralsk rayon -$7 300 074: maritime lake system –$2 800 028, middle delta- $4 500 046, Kazalinsk rayon –$5 700 256.

6.2. Direct losses in fish-breeding due to fish catch decline in different lake systems

To obtain damage in price of 2001 10 ruble/kg has been taken (or by rate of 30,14 ruble for 1$ - 332$/t). 1975 has been selected as a starting point because just in this time real decline in fish catch was found after flow regulation. Fish catch decline used for damage calculation is defined as difference between actual fish catch in specific year and maximum c fish catch in 1960-1975 – 2,3 th.t for lake systems of Kazalinsk rayon.

Average annual losses in lakes of Aralsk rayon equal to difference between value presented in previous report minus Kazalinsk rayon = $1,9mln: maritime lake system – $0,48 mln, middle delta - $1.42 mln, Kazalinsk rayon – $0,7 mln.

6.3. Assessment of direct losses in mask rat breeding

Historical maximum in mask rat catch was reached in 1965 (68 th.skins/yr). Then, due to the sea shrinking and water supply to delta decrease, mask rat catch quickly declined (down to 36 th.skins in 1970; 1 th. in 1975). Under average losses 4 $/skin average annual losses will be 68 × 4 = $272 th. (≈ $0,3 mln/yr for entire Prearalie): maritime lake system – $0.05mln, middle delta- $0.1 3mln, Kazalinsk rayon (Aksai-Kuvandarya delta) – $0.12 mln.

6.4. Assessment of direct losses in cattle breeding

Compare meat production in Prearalie and in rest of oblast during 1960- 1985 (it is 6% fro Aralskrayon and 12,5% for Kazalinsk rayon). In case if since 1990 till 2001meat production did not reach mentioned percent, there was a damage connected with cattle breeding conditions worsening.

Total damage amounted for $117 mln. And average annual damage for Aralsk rayon - $2,3 mln: maritime lake system –$0.89 mln, middle delta- $1.41 mln, Kazalinsk rayon –$5.9 mln.

Damage from milk production decrease:

Average annual damage fro Aralsk rayon is $1,2mln: maritime lake system – $0.46 mln, middle delta- $0.74 mln, Kazalinsk rayon –$2. 3mln.

Total damage from karakul skins storage in Kazakh Prearalie was $15,92 mln; average annual damage in Aralsk rayon was $0,2 mln: maritime lake system – $0.08 mln, middle delta - $0.12 mln, Kazalinsk rayon – $0.7 mln.

6.5. Assesmant of direct losses in recreation and tourism

For Aralsk rayon losses in local population recreation amount for $ 0,4 mln/yr. As to tourism, average annual damage is near $3,9mln/yr.

Thus, direct losses in recreation and tourism amount for 0,4 + 3,9 = $4,3 mln/yr.: maritime delta –$1,9 mln, middle delta-$2,4 mln.

6.6. Assessment of indirect losses in industry

Losses in fish processing industry are about 1/3 from losses from fish catch decline. With regard to previously obtained data, losses for Aralsk rayon equal to $0,6 mln/yr: maritime delta system – $0,45 mln, middle delta- $0,15 mln, Kazalinsk rayon - $0,2 mln/yr.

Losses in skins processing. Total damage from karakul skins processing decline in Kazakh Prearalie is $31,9 mln; average annual damage for Aralsk rayon is $ 0,6 mln: maritime delta system – $0,25 mln, middle delta- $0,35 mln, Kazalinsk rayon - $1,6 mln/yr.

Losses in reed processing in industrial purposes. Reed covered meadow-marshy, turf-marshy soils and soils around lakes. In Aralsk and Kazalinsk rayon total stock of reed amounted for 87.5 th. t. Presently, its processing is ceased. Under added value from its processing 30 $/t average annual losses are evaluated as $2,6mln. This damage distribution over rayons can be made proportionally to the lake area: Aralsk rayon – $2,5 mln: maritime delta system – $0,6 mln, middle delta- $1,9 mln, Kazalinsk rayon - $0,1 mln/yr.

6.7. Assessment of losses in transportation

Approximate damage value from maritime transportation decline amounts for $0,3 mln/yr: maritime delta system – $0,12 mln, middle delta - $0,18 mln/yr.

6.8. Assessment of social losses

Population migration from Prearalie is more intensive compared with Kyzyl-Orda oblast as a whole. Total damage from migration processes for the period of 1990-2000 amounts for $12,7 mln and average annual damage for Aralsk rayon is $0,4 mln: maritime delta system – $0,14 mln, middle delta- $0,26 mln, Kazalinsk rayon - $0,6 mln/yr.

Qualified personnel losses. Since 1960 till 1990 able-bodied population almost doubled but since 1991 till 1995 this indicator stabilized and within the period of 1995-2001 it reduced from 351,5 to 319,1 th.people. The first reason for this is economic situation (there is no any large industrial enterprise thus the is a problem of families members employment). Because able-bodied population grew during most intensive sea level lowering, it is impossible to calculate losses due to its reduction.

Similar situation is in losses assessment due to employment growth. It relates to the period 1996-2001 because earlier employment level was not fixed by official statistic.

Table 6.8.1
Comparative characteristic of employment in Prearalie and Kyzyl-Orda oblast, th. people

Years	Aralsk rayon		Kazalinsk rayon		Kyzyl-Orda oblast	
	Able-bodied population	Number of unemployed	Able-bodied population	Number of unemployed	Able-bodied population	Number of unemployed
1996	42,5	2,945	41,6	0,885	350	36,5
1997	38,7	2,706	37,85	0,718	318,2	36,3
1998	37,8	2,018	37,4	0,67	313,7	36,6
1999	36,5	1,078	36,8	0,63	318,6	41
2000	36,4	1,86	36,9	0,786	316,9	37,2
2001	36,5	2,107	36,9	1,55	319,1	33,4

From the table is evident that share of Kazakh Prearalie in total able-bodied population of Kyzy-Orda oblast is about 23% and in number of unemployed - 11%. Thus, situation with unemployment is more favorable in Prearalie. That's why, we do not connect unemployment dynamics with ecological situation.

Damage form population living standard decline. Its main elements except unemployment are income and production reduction. Damage from production decline has been calculated previously including losses in industry, agriculture and transport.

Table 6.8.2. Dynamics of income per capita, expenses and living wage in Kyzyl-Orda oblast and Republic of Kazakhstan

Years	Kyzyl-Orda oblast				Republic of Kazakhstan			
	Income $/capita	Pension $/capita	Expenses $/capita	Living wage $/capita	Income $/capita	Pension $/capita	Expenses $/capita	Living wage $/capita
1997	544,1	48,03	537,33	44,9	454,51	43,46	439,93	46,4
1998	522,5	45,43	527,85	42,7	432,11	50,23	428,06	44,3
1999	320,0	30,18	318,53	22,8	295,94	30,9	288,93	24,56
2000	339,41	32,14	331,66	24,95	330,76	30,88	328,37	27,73
2001	387,4	31,7	No data	25,94	467,83	32,94	No data	30,17

Table 6.8.3. Dynamics of ratio between income per capita (expenses) and living wage in Kyzyl-Orda oblast and Republic of Kazakhstan

Years	Kyzyl-Orda oblast			Republic of Kazakhstan		
	Income/ Living wage	Pension / Living wage	Expenses/ Living wage	Income/ Living wage	Pension / Living wage	Expenses/ Living wage
1997	12,1	1,07	12,0	9,8	0,94	9,48
1998	12,23	1,06	12,36	9,75	1,13	9,66
1999	14,03	1,32	14,0	12,05	1,26	11,76
2000	13,6	1,29	13,29	11,92	1,11	11,84
2001	14,93	1,22	No data	15,5	1,09	No data

It is evident that ratio between income per capita (expenses) and living wage in Kyzyl-Orda oblast is higher compared with the republic as a whole. But this increase is provided at expense of various transfers (compensation for living in worse ecological and economic conditions).

Thus, average annual damage can be defined as follow:

$$У_{комп} = (S_{п/а} : S_{рк} - 1) \times R_{рк} \times 12 \times N_{п/а}$$

Where – $S_{п/а} : S_{рк}$ – average ration between average monthly population income and living standard in Prearalie and Kazakhstan.

Average ratio between monthly income per capita and living wage in Prearalie and Kazakhstan; $R_{рк}$ –monthly income; $N_{п/а}$ – population of Kazakh Prearalie.

Taking into account, that in Aralsk rayon population amounts for 69,2 th.people, in Kazalinsk rayon – 70 th.people:

$$У_{комп\ Aralsk\ rayon}=(1,2-1)*328,37*12*69,2=5,45\ mln.\$US/yr$$

Maritime delta – 2,1 mln.$US/yr; middle delta- 3,35 mln.$US/yr

$$У_{комп\ Kazalinsk\ rayon}=(1,2-1)*328,37*12*69,2=5,52\ mln.\$US/yr$$

Beside social losses linked with its migration and compensation, it is necessary to analyze damage caused by life expectancy reduction and thickness rate growth.

According to data of Kyzyl-Orda and Kazakhstan statistic departments, average life expectancy in oblast 0,6 year (64,8 years – I oblast; 65,4 years – for entire republic). To calculate damage use methodology tested in Final Report on South Prearalie where following formula is recommended:

$$У_t = N_{п/а} \times Kсм \times \Delta T \times ВВП_д$$

Where – Kсм – death rate coefficient (7,4 per 1000 in Kyzyl-Orda oblast); ΔT – life expectancy reduction (0,6 year); $ВВП_д$ – regional GNP per capita (data of 2001 – 632, 2 $US per capita /yr).

$$У_{t\ Aralsky\ rayon} = 69{,}2 \times 7{,}4:1000 \times 0{,}6 \times 632{,}2 : 1000 = 0{,}19 \text{ mln.\$US/yr},$$

Maritime lake system – 0,06 mln.$US/yr, middle delta- 0,12 mln.$US/yr.

$$У_{t\ Kazalinsk\ rayon} = 69{,}2 \times 7{,}4:1000 \times 0{,}6 \times 632{,}2 : 1000 = 0{,}2 \text{ mln.\$US/yr},$$

Table 6.8.4
Comparative data of population thickness rate in Kyzyl-Orda oblast and Kazakhstan (diseases number per 100000 population)

Years	Kyzyl-Orda oblast	Republic of Kazakhstan	Excessive thickness rate in oblast
1997	53514,9	44484,1	9030,8
1999	64486	47972,8	16513,2
2000	64158,6	50505,1	13653,5

It is clear that thickness rate in oblast is 13 th. cases per 10000 higher compared with Kazakhstan. Under Prearalie population 139,2 th.people and average disease duration 7 days, annual labor losses are as follows:

$$13000 : 100000 \times 139{,}2 \times 7 = 127 \text{ th. days}$$

It is worthy note, that salary losses and expenses for medical treatment amount for 10$/day. Thus, total damage equals 127 ×10 : 1000 ≈ 1,3 mln.$US/yr. For Aralsk and Kazalinsk rayons: maritime lake system – 0,025 mln.$US/yr. middle delta - 0,04 mln.$US/yr.

Total average annual damage amounts for: maritime lake system – 10,41 mln.$US/yr, middle delta - 16,94 mln.$US/yr, Aksai-Kuandarya delta- 24,64 mln.$US/yr (Fig. 6.1).

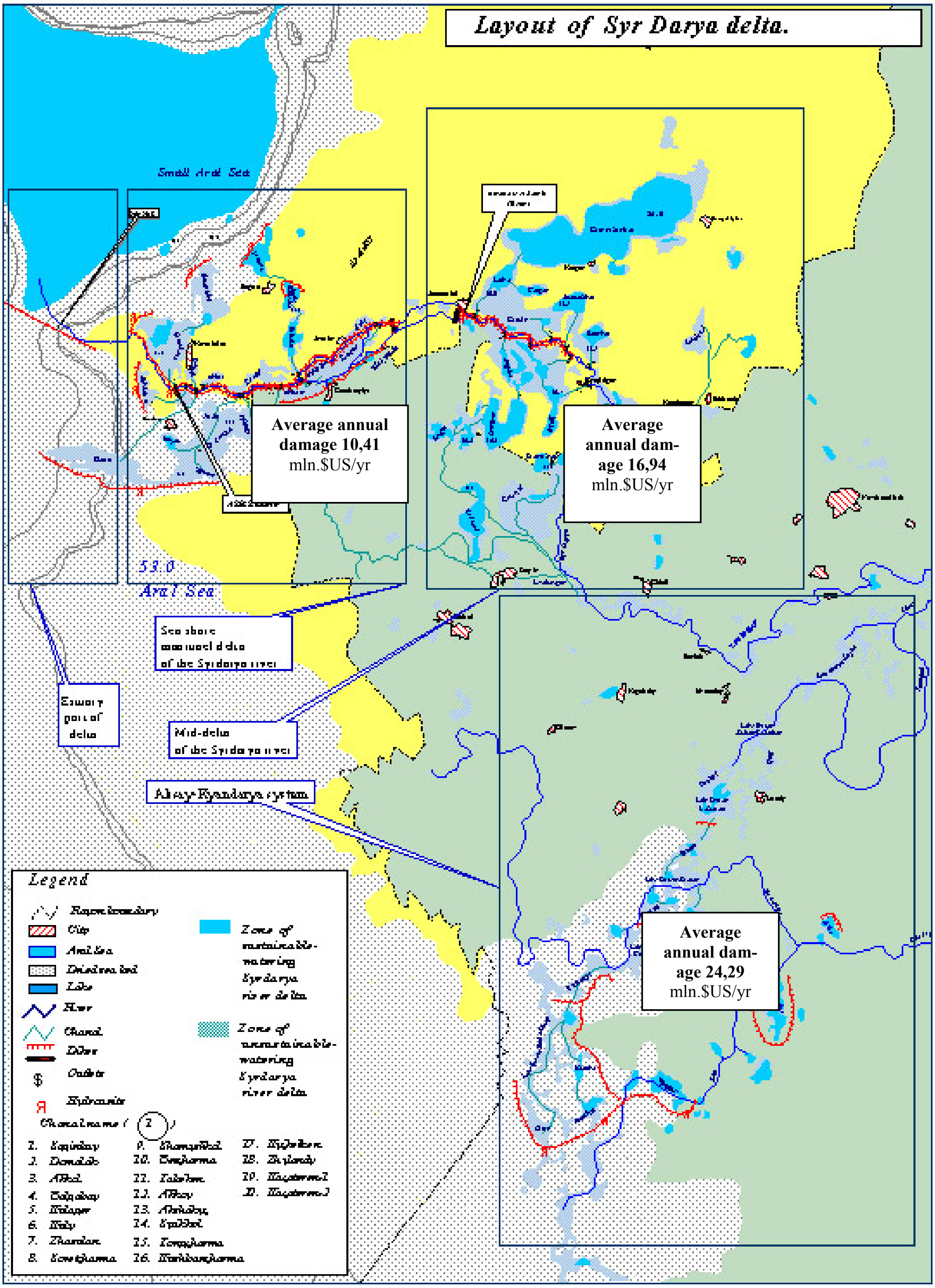


Fig. 6.1. Damage distribution over zones

Table 6.8.5
Elements of damage from ecologic disaster – Aral Sea shrinking in Kazakh and Uzbek Prearalie, mln.USD/yr

Damage elements	Kazakh Prearalie	Uzbek Prearalie
1.Losses in agriculture, total	25,8	38,31
2. Losses in recreation and tourism	4,3	11,16
3. Indirect losses in industry	5	52,42
4. Снижение объемов перевозок морским транспортом	0,3	1
5. Social losses	14,1	8,24
TOTAL	49,5	111,13

Thus, total direct and indirect social-economic losses from ecologic catastrophe in Prearalie amounted to 160,63 mln.USD/yr.

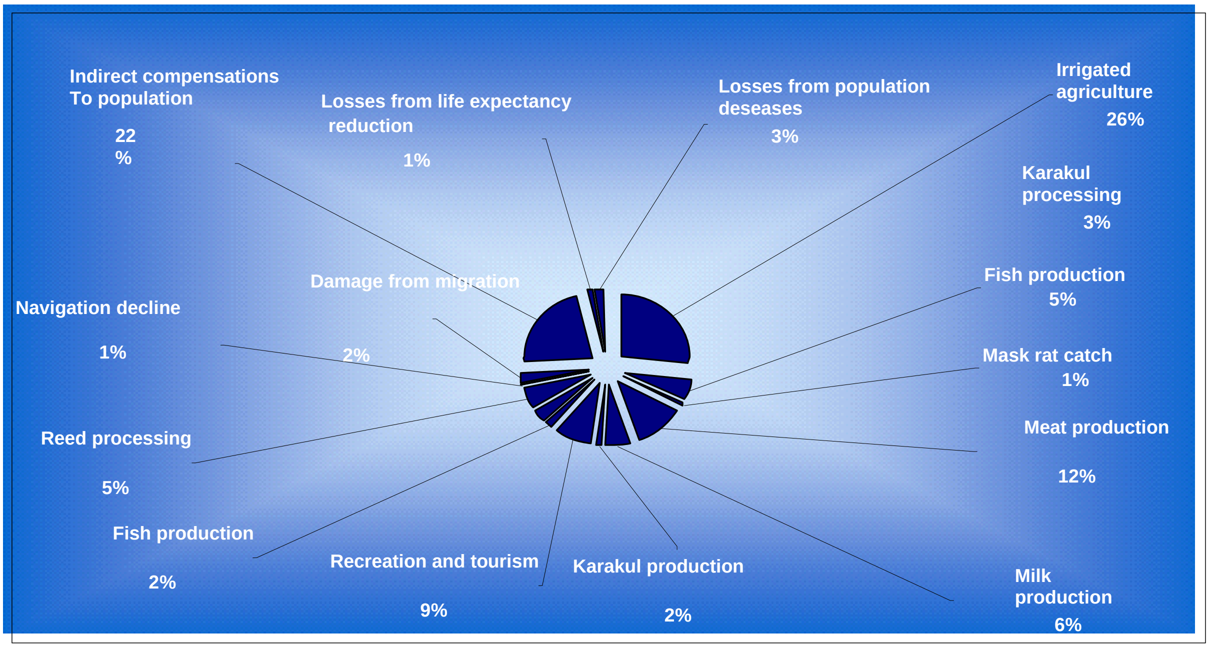


Fig. 6.2 Damage elements from ecologic disaster - Aral Seashrinking

Maximum damage in Kazakh Prearalie are connected with losses in agriculture - 27,2%, indirect losses due to compensation to population - 22,7% and meat production decline - 11,7% from total. Uzbek Prearalie has losses in fur processing - 18,4%, livestock - 11,9%, fish production - 11,8% from total.

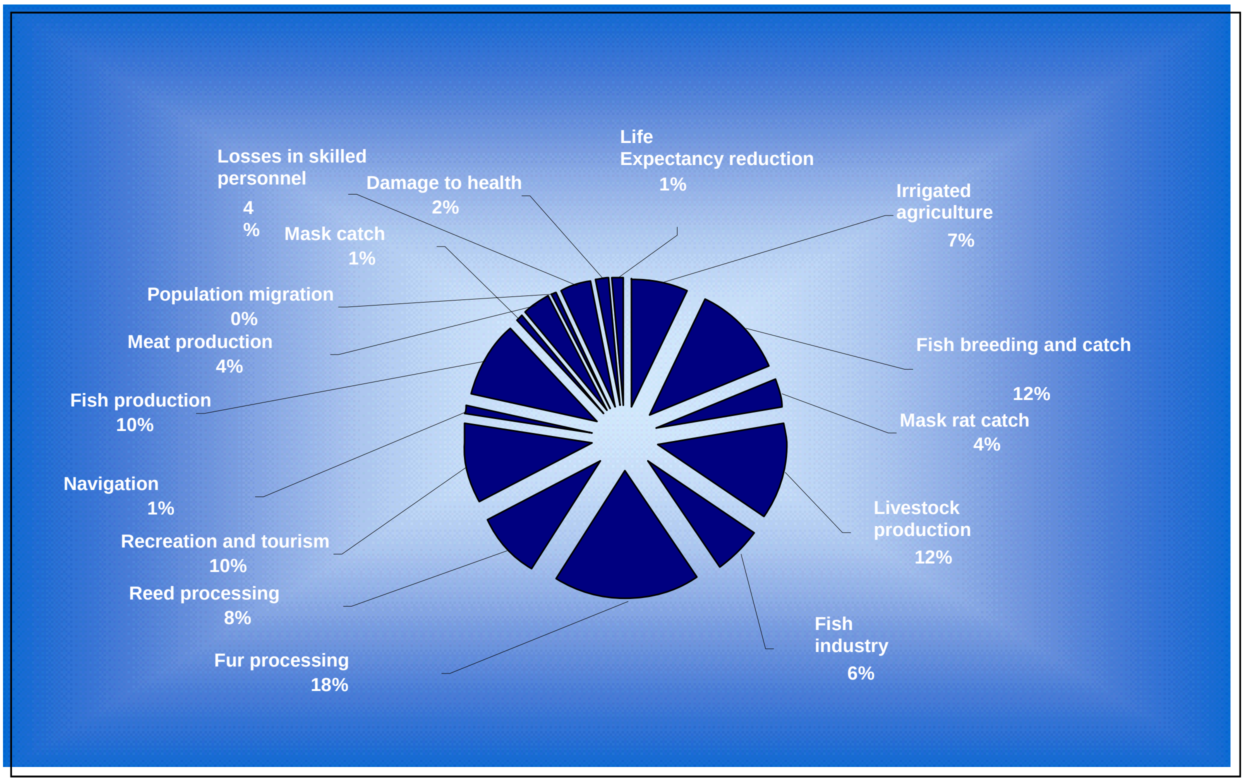


Fig. 6.3 Damage elements from ecologic disaster - Aral Seashrinking

VII. REVIEW OF PROJECTS IN SYRDARYA DELTA AND THEIR EXPECTED EFFECTIVENESS

For ecological and social-economic situation improvement in January 1994 Heads of State have approved “Program of concrete actions on ecological situation improvement in the Aral Sea basin” (ASBP-1). Main goals of this program are as follows:

- stabilizing environmental situation in the basin;
- restoring environmental situation in Prearalie;
- perfection of water ad land resources management;
- managerial structures establishing for program planning and implementation.

I accordance with this program, in Kazakhstan are accepted and realized:

- strategic plan up to 2010;
- program of poverty reduction for 2003-2005;
- national action plan of environmental hygiene, state programs “People health”;
- “Drinking water”;
- “Search of leakage”;
- “Education”, “Science”;
- “Sound life style”;
- demographic policy.

Above programs and projects implementation is directed at rational water use, and nature protection. Their funding is provided by international organizations and separate countries-donors. Donor aid to Prearalie is given by 9 countries: USA, France, the Netherlands, Great Britain, Turkey, Israel, Japan, Italy, Kuwait and 8 international organizations: UNDP, UNESCO, UNICEF, WB, EBRD, Islamic Development Bank, ADB, ILO and several charity organizations: Soros Fund, Mercy Corps, National Fund “Bobek”, etc. [7].

7.1. Review of ongoing projects (objectives, cost, terms of construction or reconstruction)

Desertification combat and environmental rehabilitation are carried out by leading Kazakh and foreign institutes. All ongoing projects can be divided into two groups:

- projects relating social-economic situation, water supply and sanitation improvement.
- projects relating new ecological profile creation.

Following projects can be placed in first direction:

1. Project «Improvement of water supply, sanitation and health in Prearalie (Aralsk and Kazalinsk rayons», is implemented by Britain GIBB jointly with Kazgiprovodhoz Project covers 134 settlements including Aralsk, Kazalinsk and Novokazalinsk with total population 150 th.people.

Project has developed water supply and sanitation options. According to this project, water pipes, treatment plants, wells should be constructed. Main water supply source is ground water from Tolagai deposit in cretaceous sediments as well as river water taken at Kazalinsk water work. Cost of water will amount for 1 $/m^3$ and with regard to sewerage system construction – 2,2 $/m^3$.

Total cost of water delivery system construction is 106,5mln.$US; sanitation – 98,3mln.$US. Duration is 10 years.

2. Project “Water supply and sanitation in the Aral Sea region” (749914 th.tenghe);

3. Project “Water supply of Kazalinsk/Novokazalinsk” (26350 th.tenghe);

4. Measures on sectoral program “Drinking water” implementation – Construction and reconstruction of rural water supply including:

- construction of Zhideli water intake (1st stage) in Kyzyl-Orda oblast (319800 th.tenghe);
- construction of Zhideli water intake (2nd stage) in Kyzyl-Orda oblast (32000 th.tenghe);
- construction of Aral-Sarybulak water pipeline (3rd stage) in Kyzyl-Orda oblast (335330 th.tenghe).

5. Target transfers (231976 th.tenghe) are allocated to Kyzyl-Orda oblast budget for local population free medical treatment.

In 1993 Kazgiprovodhoz has prepared feasibility study for Kokaral dike [8] for regulation of Small sea level and Syrdarya delta. Dam made of sand of 3m height and 12,7 km long, upper side slope 1:45 and lower side slope 1:10. Dam crest width is 10 m with gravel-crash stone filling. Filling volume is 2,8 mln. m^3. In 1993–1994 due to winter releases from Toktogul reservoir it was destroyed.

Project “Syrdarya delta regulation and development” has been performed by Italian “Italconsult” and “Electroconsult” in 1996 according to WB program [9]. Project should improve ecological and social-economic situation by Syrdarya deltaic ecosystems reconstruction. Three alternative schemes of water resources management were developed.

Proposed measures will allow make free 3.8km^3 of water for water supply to Prearalie including 700mln.m^3 at expense of irrigation system efficiency increase. It should be done by Aklak, Raim water works construction, Kazalinsk water work reconstruction, construction of dams, dikes and uniting canals.

It will allow restore deltaic lake systems on the area of 65,8 th.ha, provide water for 32,7 th.ha of irrigated lands and water supply to the Small sea in amount of 350 mln. m^3. Besides, recreation reservoir construction within Small Sarishaganak bay with capacity 70-80 mln. m^3 and altitude of 49-50 m is being planned. For this, special canal construction is suggested to take water from Syrdarya and Kamislibas lake (10 m^3/s in warm period of year).

Total cost of all measures are evaluated as 550mln.$US. Duration- 10 years.

Given project is tentative one and should serve a base for specific lows and projects. On its base Association CEG/SOGREAH/Kazgiprovodhoz has prepared project "Regulation of Syrdarya channel and Northern Sea".

Project envisages in Kazakh Prearalie:

1 - Construction of Northern sea dam
2 - Reconstruction of Kyzylorda water work
3 - Construction of Aitek structure
4 - Reconstruction of Kazalinsk water work
5 - Construction of hydrostructures in delta including:
   a) Raim water work with distributors for lake systems;
   b) Aklak water work with distributors for lake systems;
   c) recharge of Aksai-Kuvandarya lake system.
6 - Construction of Terenozek bridge
7 - Construction of protection embankments along Syrdarya river.

7.2. Main economic-technical indicators and results of above structures commission

7.2.1. Construction of Northern sea dam

Dam functions are to maintain water level at altitude 42,0m. In average inflow years resources management upstream will ensure stable inflow to Northern sea without releases. In dry years even under limited water diversion in delta level will reduce. In humid years Syrdarya discharge can exceed Northern sea capacity and water will be released to the Big sea. These releases will reduce water salinity in Northern sea. Self-washed up section is envisaged 0.5m lower dam's ridge for emergency situation.

Upon restoration maximum se surface will amount for 3,290 km2 and maximum capacity -27,070 mln. m3. After project completion water salinity will vary within 4-17 g/l. Nevertheless, expected salinity distribution will be as follow: near 65 - 70% of surface will allow to support fresh fish supply; 21% of dried seabed will be covered with water improving ecological and social-economic situation.

7.2.2. Reconstruction of Kyzylorda water work

Water work is located 905 km downstream Chardara reservoir and consists of dam, right and left bank off take regulators. It has been put in operation since 1956 and is devoted to irrigated Kyzylorda irrigation massifs. Dam capacity is 1900 m^3/s. Right bank regulator with discharge 110 m^3/s consists of 5 openings with 3 gate lines; left bank regulator with discharge 224 m^3/s consists of 6 openings.

Project envisages:

- replacement of electric equipment, fences and bridges;
- repair and rehabilitation of walls, slopes and bed of sluices-regulators made of concrete, monolith and pre-cast reinforced concrete strengthening reinforced concrete left bank dam's puddle trench by stony riprap;
- installation of new water metering equipment (level meters) in upper and lower bays.

7.2.3. Aitek water work

Water work is located 35 km downstream Kyzyl-Orda city. Main tasks of water work are following:

- increasing Syrdarya capacity at Aitek in spring peak flow period up to 1500 m^3/s and to 800 m^3/s in summer including 700 m^3/s through the river channel and 800 m^3/s through Karaozek canal;
- ensuring water supply for irrigation of 16750 ha insular lands between Syrdarya and Karaozek.

7.2.4. Kazalinsk Waterworks reconstruction

Syrdarya River delta begins from Kazalinsk waterwork constructed in 1970 in 32 km upstream Kazalinsk and 1435 km downstream Chardara with flow capacity in normal conditions and the head at threshold 5 m – 1000 m^3/s, and in forced conditions with the head at threshold 6 m – 1600 m^3/s.

The waterworks consists of the dam itself with 5 spans 16 m long with two lines of grooving structures and fixed roller gates 5 m high. Four end spans are equipped with flushing galleries overlapped by flat gates with twin-screw elevators, middle span serves as fish passage, therefore, it is equipped from below with the third line of gate with chain elevator. At height 15 m from the dam threshold there are elevated ramps, where elevating mechanisms are fixed. Right-bank (flow capacity 85 m^3/s), Left-bank (100 m^3/s), Aksay (30 m^3/s) sluice off take regulators are overlapped by tunnel type fixed gates 3 x 6 m.

The project assumes:

- repair of head race, aprons, and outlet wing training walls;
- repair of floors and lower bay fastening of all three water intakes;
- lengthening of apron fastening;
- repair of all gates and elevating mechanisms on dam ;
- replacement of all gates and elevating mechanisms of sediment intercepting galleries in Right-bank and Left-bank sluice off take regulators;
- renewal of all electric technical equipment;
- installation of new level gauges;
- reinforcement of left guide bund in head race channel at length 300 m.

7.2.5. Aklak Waterworks

Former Aklak sluice off take regulator constructed in the end of 70-ties as temporary structure was designed for maintaining appropriate head to supply water in lakes and flood hayfields. It is located at distance 1628,5 km from Chardara reservoir. Currently the structure is in unsatisfactory state and can be destroyed at any time. Also it restricts inflow from the river in NAS to 60m3/s. Given structure has been abandoned and is not operated because it can collapse and has limited flow capacity.

Aral Sea desiccation resulted in excessive erosion of Syrdarya River downstream structure that led to formation of canyon with depth 8-10 m. This fact negatively impacts on state of coastal right- and left-bank lake systems (inflow decrease caused by level lowering in Darya that led to reverse flow from the lakes, ground water contribution decline, and finally, lakes' drying up).

New structure is designed for water supply of lakes and hayfields in delta lower reaches (right- and left-bank coastal lake systems), stopping river channel destroy as well as for providing river flow capacity for inflow in NAS. Aklak water work will be constructed nearby existing structure with two outlets 12 and 25 m closed by sector gates with height 6 m. Elevators located on specific elevated ramp will be used for elevating and descending gates. Spillway, floor, and apron will be made of reinforced concrete. The river will be connected with water work by means of unlined head race and tail race. Concrete drop structures will be fixed in riverbed downstream waterworks will cancel hydraulic gradient as well as protect channel from further collapse.

It is planned to rehabilitate additional 15 water intake structures upstream waterworks to supply lakes and hayfields with water.

7.2.6. Check dams

The project assumes:

- rehabilitation of existing dams and construction of new ones.;
- river-channel straightening on three sites near Aksu village at 1037 km (length: 3500 m); about 1070 km (700 m); and at Belsendy village at 1082 km (1.5 km);
- measures on protecting Kysyl-Orda city.

Designed and reconstructed dams were constructed of local ground with compaction, width 3,50 m wide on crest, side slope: upstream face – 1:3, downstream face - 1:2,5. Each 2,0 km passing places with 8,0m wide and 150 m long are foreseen for O&M service vehicles passing.

Total length of dams along Syrdarya:

- under reconstruction - 321,1 km;
- new - 179,7 km.

7.2.7. Chardara Dam rehabilitation

Rehabilitation includes such important works as reconstruction of Kyzylkum water intake, drainage system, gate valves, repair of spillways, head race channels, cushion pools, and support works as well as equipment installation on dam.

These activities compose the first phase of Chardara Dam rehabilitation to ensure its safety in the nearest future that will reduce water losses, increase water supply of irrigation and other sectors as well as extend power generation.

Unfortunately, very important objects have been excluded from the project first phase: Raim Water works, and Aksay-Kuvandarya lake system inflow.

7.2.8. New waterworks construction on Syrdarya River in Raim settlement zone

New waterworks construction on Syrdarya River in Raim settlement zone at distance 1567,7 km from Chardara reservoir. Designed flow capacity of waterworks in summer regime is 514 m^3/s, winter – 395 m^3/s. Waterworks is constructed of monolithic and reinforced concrete. Waterworks spillway consists of low-head dam having two water outlets, which closed by sector gates with width 16 m and height 6 m. Elevating and descending of gates is expected to carry out by means of elevator drive located on specific elevated ramp. In lower bay dampener is foreseen in form of cushion pool as well as apron made of precast reinforced plates.

Left-bank (discharge is 44 m^3/s) and Right-bank (discharge is 20 m^3/s) sluice off take regulators are presented by two or one outlet appropriately closed by flat gates with width 6 m and height 3,5 m. To elevate gates twin-screw electrical elevators are designed. To fill piscicultural lakes of Kamyshlybash (on the right bank) and Akshaut (on the left bank) lake systems as well as watering of hayfields and environmental delta complexes distribution canals in earthen channel with length 11,5 and 4,3 km and width 8,0 and 15,0 appropriately go away from Right-bank and Left-bank sluice off take regulators. Upstream along the river two right-bank canals are designed for discharge from 3,0 to 7,0 m3/s consisting of rectangular precast reinforced pipes, which are close by gates, are designed. At that gates' design for the right bank will have bilateral function.

7.2.9. Aksay-Kyandarya lake system inflow

Aksay-Kyandarya lake system inflow is supplied with water from Aksay canal, which headwork is located on the left-bank of Kazalinsk Waterworks (30 m^3/s). Presently area of former lakes Lakaly and Zhanay-Sandyrbay is 4500 ha and used mainly for hay production. To rehabilitate these lakes construction of two earthen dams Bozkol and Kaukey with water outlet as well as construction of low dams with height 32.5 km for lakes' protection is recommended. Thus, total lakes area will be 20000 ha, besides, hayfields on area 5800 along with environmental complex with area 5500 ha should be supplied with water within this system. Total system water consumption is 427 mln m^3 per year.

7.3. Expected benefits from construction and their reality

7.3.1. North Sea Dam

Let us consider North Sea Dam. Benefits:

- partial restoration of North Aral Sea at sublevel in result of future inflow based on measures on water saving only in Kazakhstan;
- partial restoration of fish-husbandry in NAS;
- seawater salinity reduction;
- salt transfer reduction and health improvement;
- air humidity increase and summer temperature lowering in NAS zone.

As a result it is planned that guaranteed fish catch amount will be minimum 1900 tons per year, maximum 5600 tons.

Environmental reservoir impact:

- within dried seabed from total area 664 626 th.ha of former Small Sea between altitudes 53 and 39 m existing sea area is 249 840 th.ha, unstable landscapes are (368,4)? th.ha, they at normal pool level 42 m are flooded by water surface – 310,5 th.ha, and additionally 3,2 th.ha are water logged with regard to biofouling, in total 313,7 th.ha or 10%.

- moreover, on estimates of local regulatory bodies, water doesn't reach Aralsk town at distance 20 km that doesn't solve the problem of stable water surface area formation in urban zone, the problem of infrastructure improvement, industry restoration, population employment, and environmental situation improvement in the town, where population constitutes about 60% of rayon population.

As calculations of A.G. Sorokin, presented in the report on INTAS-Aral-1105 Project, show during transition period to integrated water resources management within Syrdarya basin on optimistic scenario reaching altitude 47,5-48,0 m in Small Sea is quite feasible that will allow reducing of unstable landscapes' area on dried seabed already by 73 th.ha plus 50 th.ha due to water logging, in total about 120 th.ha or almost half of earlier unstable landscapes within sea zone

Thus, problem of coastal zone at altitude 47-48 m would be effectively solved, at that time sea surface area would increase by 126 th. ha!

7.3.2. Aklak waterwork and structures

The project assumes that in result of restoring 9 water diversion structures and supporting waterworks at altitude 53,5 m stabilization of lakes area 6260 ha, hayfields area 5980 ha as well as maintenance of environmental complex area 19036 will be achieved. This allow provide:

- Improvement of social-economic situation in the region by means of:
  - fish-husbandry enhancement;
  - cattle head increase and improvement of animal living conditions;
  - reduction of hayfield and pasture lands salinity;
  - biological variety increase in Syrdarya delta.
- Prevention of riverbed erosion processes, which have already reached depth 10 m and will continue upstream, if planned measures won't be carried out.

However, all Coastal delta ("b" zone) systems remain uncontrollable and lacking canal systems, since they are not stipulated in the project.

There is no convincing grounding of adopted project decisions on delta objects in the project. Construction of Aklak spillway dam will provide water availability increase for coastal (right- and left-bank lake systems). At the same time detailed study of system objects inflow scheme, engineering structures system to protect settlements from flooding, is not available.

Analysis shows that these structures provide watering of recommended area under project not entirely, since the project stipulates just reconstruction of 8 canals and headwork on these canals. In this zone 3 canals more to be rehabilitated, dam construction (about 22 km long) in tail parts of lakes and spillways to provide lake system flowage. Also the problem of connecting channels of the lakes. As for command water supply of lake systems by waterworks, this problem will be solved successfully enough, since all lake systems levels are below 52,5 m, and waterworks level is supposed at 53,5 m.

It is necessary to note that in this zone on base of data of satellite images extra 4,5 th.ha of environmental complex can be watered, from them 2,5 th.ha – lakes (maximum possible wetted area in this zone is 32,4 th.ha).

Raim Waterworks and supporting structures turned out to be very important element of delta (“b” zone) water supply stability – its Komyslybas and Akshaut lake systems, which are the most fish-productive presently. The project assumed that waterworks at normal pool level 59,07 m will provide by means of two channels: right-bank with length 11,5 km and left-bank – 4,3 km stable water surface here with following indicators:

Consumer	Supply area without Raim Waterworks (ha)	Water supply area after Raim construction (ha)
Lakes	25,000	39,465
Hayfields	3,436	6,920
Environmental complex	2,400	5,481

Due to lack of funds this object was excluded from the first phase, and practically all Middle delta remains in the same state.

According to the first draft project this waterworks was stipulated with costs for this object construction in amount 12,7 mln USD. Earlier in this zone about 40 th.ha of environmental complex, including 35 th.ha – lake systems – was watered. Under Raim Waterworks construction the project assumed to water 46,4 th.ha of environmental complex. Analysis of this project effectiveness shows that it is not able to water total foreseen area. The project didn’t assume reconstruction of 7 canals as well as their equipping with appropriate engineering structures; dams with length about 12-15 km; connecting channels between lakes. Therefore the project is to be revised to solve the problem totally. The project stipulates to establish waterworks operating level at altitude 59 m. This will give opportunity to supply water for all lake systems within this zone, since maximal lakes altitudes are at 56,4 m. Basing on presented data in table 1 on maximal zone watering one can say that in this system beside environmental complex area (46,4 th.ha) extra 6,0 th.ha can be watered. All extra-area correspond to lake systems in this zone.

7.3.3. Aksay-Kuandarya system – ("d" zone)

In this zone in recommended project Kazgiprovodkhoz assumes to water 25,8 th.ha of environmental complex, from them 5,5 th.ha correspond to lake systems. Cost of this zone rehabilitation with regard to 5,5 th.ha of irrigated lands is 6,2 mln USD. Here Aksay flow channel rehabilitation from Kazalinsk Waterworks, Aksay River regulation by two earthen dams Bozkol and Kaukeb appropriately with flow capacity 5 m^3/s and 10 m^3/s is supposed. In result it is planned to carry out:

- rehabilitation of 20,000 ha of piscicultural lakes;
- systematic watering of 5,800 ha of hayfields;
- maintenance of 5,500 ha of environmental complex.

Actual role of these structures is not quite identified regarding their effectiveness in this delta. Moreover, Kuandarya riverbed is not developed in engineering aspect, but 8 lakes difficult to be regulated are located at long distance just right there.

The project didn't suppose 9 sluice off take regulators in tail parts of the lakes on this canal. Taking into account (according to space image data in table 1) maximum possible watering area is 43,5 th.ha of environmental complex in this zone, from which 23,5 th.ha belongs to lake system. There is extra 17,7 th.ha of environmental complex in this zone, from which 3,5 th.ha are also lake systems.

7.3.4. Aytek complex and Karaozek structures

By means of new regulatory structure on Syrdarya at altitude 123,0 m, the old structure is closed by dams. By means of headwork reconstruction on Aytek canal (50 m^3/s) headwork reconstruction on Karaozek channel (60 m^3/s) and reconstruction of all structures on the sam channel liquidation of insufficient Syrdarya flow capacity in the place of its division into two channels Zhamandarya and Karaozek; regularly flooding of areas adjacent with this river; inability under low water levels in river during low water periods to divert water in Aytek canal, which waters irrigation areas, providing continuos water supply of irrigation area 16,750 ha from Aytek canal, irrigation area 3,360 ha from Karaozek channel, hayfields' area 20,350 ha, piscicultural lakes area 587 ha, pasture area 80,000 ha, environmental complex area 1,350 ha.

Due to all that following will be provided:

Summer regime: in low water periods (discharges up to 300 m^3/s), Aytek Waterworks provides sufficiently command level, which allows to divert water in Aytek canal (maximum discharge 50 m^3/s), Karaozek channel (maximum discharge 60 m^3/s), Syrdarya lower reaches. Discharges up to 700 m^3/s are coming with Zhamandarya, i.e. through main channel. Under high discharge in flooding period water is diverted through self-washed out dam in Karaozek channel head section and destroys it increasing in that way water discharge in Karaozek up to 800 m^3/s. After flooding this dam is restored.

Winter regime: maximum winter discharge on the structure is 450 m^3/s. About 390 m^3/s will be discharged over Zhamandarya, rest 60 m^3/s will come to Karaozek channel. According to hydraulic calculations, currently Syrdarya can pass in winter about 400 m^3/s except section of 40 km in Zhusaly zone where check dams are to be constructed.

Expected costs for this measure: 16 656 000 USD.

However, issue of water availability increase in lake system upper delta part along Syrdarya right bank (lakes Makpal, Kokshikol, Daunkol, Aynakol, Zhangabyl, Tastak, and Kandyozek) wasn't decided yet.

In general, assessment of sustainable functioning effectiveness for delta complex after the project implementation is not quite clear and just.

If compare presented under the project data with data from table 1, following situation can be seen:

- **over "b» zone** it is expected increment of lakes area 6,26 th.ha, actually even in low water 2000 year lakes area in Coastal delta was not zero, but 4,2 th.ha. In the highest water years lakes area reached 11-13 th.ha, wetlands area – 26,0 th.ha. It is necessary to identify, which lakes and environmental complexes will be wetted, filled up and how;
- **over "c" zone** figures are closer to remote sensing data, but, in first, Raim is not included in the project, in second, scales and volumes of complex have not been determined clearly.
- **over "d" zone** in Aksay-Kuandarya delta even in the lowest water year lakes area on remote sensing data will be 24,6 th.ha, and in the highest water years up to 45 th.ha. Bigger increment can be reached, since maximum wetland area exceeds 52 th.ha, however it is necessary to determine how and by means of what structures it will be reached.

VIII. EXPEDITIONS RESULTS AND ACTION PLAN

8.1. Visual inspection of Northern Prearalie objects

Two research expeditions carried put by team CR-2 in 2002 and 2003 years allowed clarification on each zone considerations of local municipalities, experts, and population.

Zone "a":

- In Aralsk and its surrounding population migration including fishermen practically stopped. Due to sponsors' help production fishery cooperatives have proper equipment for fishing. Plaice acclimatization in Small Sea, conducted workshops and fish trade fairs promoted strengthening of fish-husbandry confidence and activity. Also oil production in several delta places (Kuldy and Atoshyn) as well as shipyard re-profiling to car-repair plant promoted social prosperity increase. Development of local production (cheese, brynza, hen, meat, etc.) has started (Akim of Aralsk rayon).

- Sea fish-breeding requires its culture rising, processibility, and stability. Earlier production to 5 centner/ha was achieved, now initially 1,0 is planning, and nobody actually counts fish catch in the lakes. Record value is 0,1-0,2 centner/ha! Nevertheless, annual plaice catch is 1000-1250 tons, and total fish catch is up to 5000 tons! (KazNIIRH Aralsk branch).

- Under Danish Fund "DANIDA" support by forces of NGO "Araltengiz" since 1998 forty fishery cooperatives and 106 brigades of private persons were organized. Fishermen are working actively enough (NGO vice-president).

- Cattle-breeding is being developed intensively in rayon. There are 24 heads of cattle, 120 th. sheep and she-goats, 13 th. horses, and 15 th. camels. Big increment of cattle can be observed: 75 heads of calves from 100 cows, 105-106 lambs from 100 sheep, 70 foals from 100 horses, 43-45 young of camels from 100 camels. In spite of low productivity of small cattle cattle-breeding is the main source of family farms' development (rayon agricultural authorities).

- Altitudes below 42 m form reservoir, which doesn't reach the city 27 km. The level must be raised, and connection with reservoirs located near the city must be provided. It is important that under altitude 47 m reservoirs can be filled from Small Sea (deputy Akim of Aralsk rayon).

Zone "b":

The first problem – waterworks' construction on Balgabay canal, feeding from the river and supplying water for the settlement and whole lake system locating in this court (area is about 5000 ha).

The second problem – spillway construction on 1800-meter dam, which was built by population around anthropogenic lake Sarteren to release extra water from this lake towards the sea, providing at the same time flowage of all lake systems of this zone.

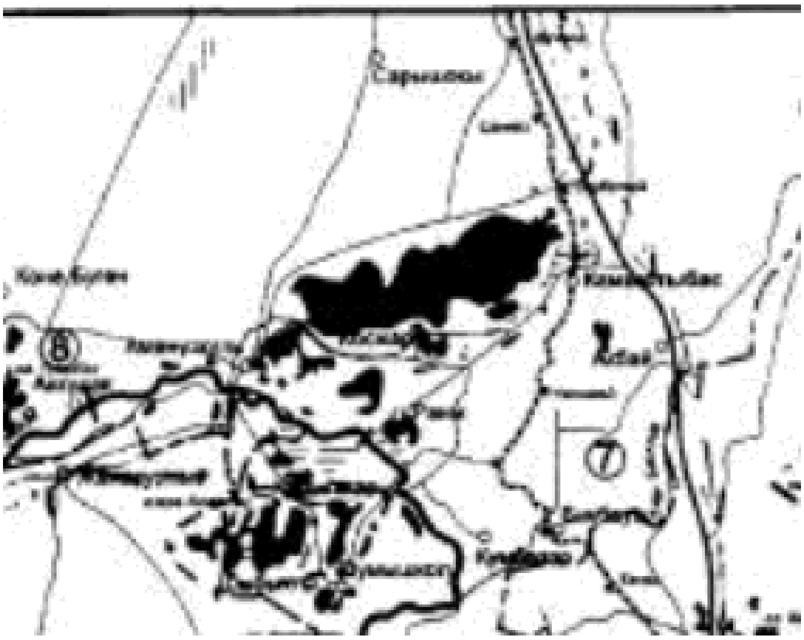
The third problem – the fortune of three lakes: Karashalan, Sapuan, and Shoshkaaral, which earlier fed from Saginbay canal. Presently due to Aklak breaching all three lakes desiccated. After Aklak construction these lakes can be rehabilitated, but the problem is a lack of dam in tail part of Sapuan lake and spillway. Therefore Sapuan lake tail part must be reinforced by the dam and spillway (the place is called Akchukat, the project assumes here the sluice offtake regulator for flow capacity 50 m3). This will allow restoration of almost 2000 ha of lakes area and about 4000 ha of hayfields as well as water supply of settlement Karashalan (75 yards, more 500 people), which has no water now (Akim of Amanatkul rayon).

- It is necessary to solve problem of lake systems, build water diversion structure on Tongzharma canal to divert water from the river and sluice off take regulator on Kushbanzharma canal to release extra water to provide lake systems' flowage. Moreover, the dam from the river side should be strengthened to prevent water inflow to the river channel (these works are stipulated in the project). (Akim of village court Zhanakurylis)

After cofferdam destroy and, in particular Akalak Waterworks destroy, all lake systems located on area of this court dried up and disappeared. People started leaving settlement for other areas because of lack of job places, especially fishermen, who dealt with fishing and fish sale. The court Akim asks to rehabilitate all waterworks located on all canals, especially on canals Karateren 1 and 2 (stipulated by project) as well as spillways' construction in tail parts of Kartma lake, Bayan lake and others. (Akim of village court Karateren)

Zone "c" – Middle delta:

Kamyslybas fish hatchery. Kamyslybas lake is a main source of population well-being in Aralsk rayon.



Kamyslybas lake is mainly filled in spring period with clean water from Syrdarya. Presently there are 4 small lakes (Laykol, Kayezdy, Zhanakosh, and Raim) connected by channels and head race channels from Syrdarya. These channels in summer time are blocked to avoid water self-outflow from Kamyslybas system. Presently three channels are operating and the fourth channel is under construction (Sovetzharma). Water flows in Kamyslybas lake from Laykol lake.

Total lake system area under normal filling up is 18 th.ha. The fish hatchery staff is 70. The fish hatchery capacity is 12 mln. Newly-hatched fish per year. This year 3,5 mln newly-hatched fish has been produced for lake system. The fish hatchery staff, population from Koszhar village and Aralsk rayon believe that Raim Waterworks and water diversion structures building on head race channels to lake systems will allow providing stability of lake system area, and appropriately increase of productivity per 1 ha fish areas. (Fish hatchery staff).

Due to lack of structures on fish hatchery systems several times, when water level has declined, all fish released from fishpond left for Darya and further to the sea. This became obvious, when fishermen caught a lot of fish of standard size. In this connection akim insisted on helping in construction of the structures on canals, which provide lakes' filling from Syrdarya.

We carried out investigation of Kamyslybas lake system regarding its water availability. Finally we made a conclusion that on Sovetzharma canal (canal altitude 56 m), where water diversion from Syrdarya is fulfilled, to fill this system hydrostructures are to be constructed to maintain water volume and level in lake systems under level lowering. Here on the canal, which connects Loykol lake with the river, sluice off take regulator with fish barrier should be built to preserve fish supplies in lake system. These hydro-structures will improve lake systems' flowage, and give opportunity of fish productivity opportunity in these lakes.

Laykol lake is an end one in middle delta. When water level in Laykol lake reaches 53 m, because of lack of sluice off take regulator water begins to wash the dam away and, therefore, it is necessary to build sluice off take regulator in this lake, build up the dam along Syrdarya river bank (Akim of Aminatkul village court).

Akshatau lake system includes following lakes: Aitkul, Chilandykul, Chabankul, Zharkul, Suykkol, Akshakizkul, Tabekenkol, and Krakul. Total area of these lakes is more 10.000 ha. Akshatau lake is the biggest from them. Its area is about 5-6 th.ha, depth is 10-12 m. Examination of these lakes shoed that all engineering structures of these systems are totally destroyed. We saw the water returning from the structures to Syrdarya. Akim asks to restore all structures both inlet on Beszharma canal and outlet on Akshakyz canal.

Raim village court population by own forces rehabilitated dried lake Shomushkul and organized there fish catch, however it askes to build engineering structures on the canal, which inflows to the lake, and on Beszharma canal, which supplies water to Karakul lake.

When Darya water level declines and water begins to come back to the river, population asks to help in blocking canals to maintain normal water level in purpose of fish supplies conservation in lake systems. In many canals existing waterworks were destroyed, and many canals were constructed without any engineering structures, and therefore these canals have to be blocked by earthen embankment. Sometimes, because of equipment shortage we have no enough time to close some canals, and then many lake systems started to dry. For example, such situation can be observed with three lakes Akbasty, Uchaidyn, Karakol of Zhanakuryly court as well as lakes Akshakyzkol, Suykkol, Tabakekol, Karakol (Akshatau lake system), and many others. (K. Ulikbanov, “Meliorator” association)

Zone “d”:

Aksay system:

- Zhubansadyrbay lakes with total area 4000 ha presently are almost dried because of water lack; earlier in tail part they were closed by dams, but the dam collapsed, and spillway structures are to be built. All lake area is covered with reed;

- on area adjacent with Sagir settlement two lakes Aktash and Sashirbali with area about 4000 ha are located. Surrounding dams collapsed, and there is no waster in the lakes;

- not far from the bridge across Kuvandarya blind cofferdam was built to feed anthropogenic Akkul lake and Mariya lake for fish-husbandry goals. Currently due to river level decline water from the lake returns to the river. Blind cofferdam should replaced by sluice off take regulator to supply two lakes.

Bozkol tract (former bay), which area is about 8000 ha, is covered with reed. It is impossible to reproach to this lake because of swamp forming around it. It is necessary to carry out water and environmental measures to rehabilitate and preserve the lake (the sluice offtake regulator should be installed in the head part, and spillway dam – in tail part).

Uzyak lake is anthropogenic with inflow through Kosa canal, which is 2 km long, from Mariya lake through sluice offtake regulator (5 m^3/s); it was formed on base of Kashkansu lake, which area is about 2500 ha. Not far from Kashkansu lake Manay lake is located. Its area is about 2000 ha, depth is 1,5-2 m. On this lake dams also collapsed, water returns to the river. It is required to carry out water conservation and environmental measures to preserve it (these lakes must be integrated, and between them sluice off take regulators should be installed as well as spillway dam must be built in tail part of the lake).

And finally, Kaukey lake, which area is more 7500 ha with many floods, because of lacking sluice off take regulator and cofferdams in tail part releases all water flooding towards Big Sea.

Results of above mentioned research expeditions allow making list of appropriate structures and activities on local experts' opinion, which is presented in table 8.1. It is clear that this set is very tentative, but it allows defining amount of expected investments demanded for maintaining sustainable reservoirs regime.

Table 8.1
Additional activities in Syrdarya river delta

Zone and Object	Appropriate additional activities in Syrdarya river delta		
	Dam construction, (length) m	Construction of new hydro-structures	Reconstruction of old hydro-structures
Coastal delta:			
Sarteren Lake	in tail part - 1800	sluice offtake regulator	
Shoshkaaral Lake	in tail part -2600	sluice offtake regulator	
Akbelek Lake	in tail part - 2200	sluice offtake regulator	
Kartma-Kuyulys Lake	in tail part - 600	sluice offtake regulator	
canals: Balgabay	-	water diversion str.	yes
Tongzharma	-	water diversion str.	yes
Kushbanzharma	-	water diversion str.	yes
Syrdarya River	on site of Zhanakurylys set.- 7800		
Syrdarya river Middle delta	On Amanatkul set. site – 10000	Raim waterwork	Raim spillway dam
	-	water diversion str	
	-	sluice off-take regulator	
	-	sluice off take regulator	
	-	water diversion str.	
	-	water diversion str.	
	-	water diversion str.	

Zone and Object	Appropriate additional activities in Syrdarya river delta		
	Dam construction, (length) m	Construction of new hydro-structures	Reconstruction of old hydro-structures
Aksay-Kuandarya			
Zhuban-Sadyrbay	Yes - 800	sluice off take regulator	-
lakes	Yes - 1100	sluice off take regulator	-
Lakhaly Lake	Yes - 650	sluice off take regulator	-
Zhanay Lake	Yes - 1600	sluice off take regulator	-
Kurdym Lake	Yes - 2100	sluice off take regulator	-
Kazhamberli Lake	Yes - 1800	sluice off take regulator	-
Ishankol Lake	Yes - 900	sluice off take regulator	-
Karakol Lake	Yes - 450	sluice off take regulator	-
Akkol Lake	Yes – 1200	sluice off take regulator	-
Mariyamkol Lake	-	-	yes
canals: Kosa	-	-	yes
old Kuandarya channel	-	-	yes
Kazalinsk waterwork	At distant point 12 to build up the dam by 2100		At distant point 13 water distribution canal, All sites, gauging posts

Table 8.2
Water consumption and funding amount for additional watering area of environmental area

Systems	Watering areas under project		Additional watering areas on proposals		Demanded water amount for complex and construction costs		Demanded water amount for complex and costs for additional area	
	Environmental complex, th. ha	Incl. lakes, th. ha	Environmental complex, th. ha	Incl. lakes, th. ha	Water amount, mln. m^3	costs mln. USD	Water amount, mln. m^3	costs mln. USD
Small Sea	60,710 (249,840)		206,450		3000	23,19	5000	78.85
Coastal delta	19,75	6,2	7,25	4,73	261.8	17.6	265.8	6,4
Middle delta	46,4	40	23,72	7,91	765.1	12,7	765.1	6,9
Aksay-Kuandarya	25,8	20	38,69	23,87	693.5	6,2	693.5	9,2
In total on delta:	91,95 (152,66 taking into account)	66,2	69,66 (276,11 taking into account)	36,51	4720.4 taking into account	59,69	6724.4 taking into account	101,35 taking into account

In Kazalinsk rayon WUA "Erdos" has prepared by own forces the project "Watering of Aksay-Kuandarya lake system to rehabilitate and preserve greenbelt in this region". This project assumes all appropriate water conservation and environmental measures with construction of different hydro-structures to rehabilitate and preserve greenbelt over Aksay-Kuandarya system. The project is designed for a year with total required amount for the project implementation 14 mln. tenge (about $90 th.).

8.2. Action plan and expected outcomes

1. Syrdarya River basin states have to agree about common development direction, water regimes in the river, and allocation of limits for supplying environmental complex with water, including formation of North Aral Sea. From these positions, water requirements of lower reaches (downstream Kazalinsk waterwork) have to be discussed and approved. These volumes have to be calculated and presented for approval by all 4 basin states as obligatory condition of environmental flows.
2. Taking into account all Syrdarya basin states adopted optimal development scenario, it is expedient to revise water amount in NAS up to altitude 47-47,5 m to maximally draw water surface area to Aral Sea as well as create opportunity of filling Sary-Chaganak.
3. Specific detailed field studies are required in Syrdarya lower reaches and North Aral Sea to ground in scientific-engineering aspect and carry out measures on maintaining and regulating water-environmental situation in region. By means of modeling tool it is necessary to work out in detail and amplify composition, volumes, and regimes of reservoirs and connection channels' operation, since creation of manageable wetlands in Syrdarya lower reaches hasn't been studied enough. It is demanded to ground clearly: which lakes, in which parameters (surface area, depth) and with which inflow regime should be preserved and which lakes - because of inexpedience of further use – should be excluded.
   Conditions of regime and five structures should be linked with Syrdarya operation regime, since with its emptying sluices in the lakes work in reverse direction.
4. In addition to the top-priority objects outlined for funding by World Bank it is expedient to provide Raim Water works construction as well as broad development of delta lakes infrastructure, connection channels, and dams. Preliminary amounts of investments and water consumption are presented in the table 8.2.
5. It is necessary to establish Consortium or other water association on delta management, which will work with involvement of all stakeholders as well as governments and oblast organizations. This body has to build interrelations with BWO "Syrdarya" based on the contract with payment of mutual services and clear definition of mutual responsibilities.

IX. PRELIMINARY ASSESSMENT OF MEASURES ON REGULATED WATER BODIES CREATION IN SYRDARYA DELTA AND DRIED ARAL SEA BED EFFECTIVENESS

As it was shown in interim report for 2003, set of measures includes construction of lateral dam in Berg strait for the Northern sea rehabilitation (23,19 mln.USD) and natural complexes rehabilitation in Syrdarya delta. Aklak structure (17.6mln.USD) construction is most important for Kazalinsk headwork (4.1 mln.USD) and Aksai-Kuvandarya lake system (6.2 mln.USD) rehabilitation. Thus, total capital investments will amount to:

$$23,19 + 17,6 + 4,1 + 6,2 = 51,09 \text{ mln.USD}$$

From scientific report of Kazakhstan Ecological NGO (Phase 3) is obvious that dam is planned to be built during 2 years. On the other hand, in 2003 phase 1 of the project (total cost is 85.79 mln.USD, duration – 5 years) implementation has been started. Thus, annual optimistic amount of financial means spent is 17 mln.USD and realization of measures on regulated water bodies creation will take 3 years.

According to available, main outputs will be following:

- water level stabilization in Northern sea;
- ecosystems degradation in Syrdarya delta and adjacent area is stopped;
- agricultural production and fish production industry are restored;
- population living standard is improved;
- Syrdarya delta biodiversity is increased.

It worthy to note, that planned set of measures is aimed at ecological disaster damage prevention in Kazakh Prearalie. From previous calculations is evident that total average annual value of such damage is 51,99 mln.USD, including: maritime lake system - 10, 41 mln.USD, middle delta – 16,94 mln.USD; Aksai-Kuvandarya delta – 24,64 mln.USD.

Damage structure is as follow:

52% - losses in agriculture;
9% - losses in recreation and tourism;
11% - indirect losses in industry and transport;
28% - social losses.

Analysis showed that dam construction together with natural complexes rehabilitation in Syrdarya delta will allow reduce losses by 40% in agriculture, 50% - in industry and transport and all social losses. At the same time, these measures will not restore recreation and tourism in Kazakh Prearalie. Thus, average annual effect from these measures will amount to:

$$(0,52*0,4 + 0,09*0 + 0,11*0,25 + 0,28*0,25)*51,99 = 15,9 \text{ mln.USD}$$

On base of data available let us calculate economic effectiveness of these measures. To take into account risk factor, we use "sensitivity analysis". From the theory of this method is known that its three modifications are most widely spread:

- method "analysis of elasticity" (is based on evaluation of key indicators changes under most important parameters' 1% change);
- method "critical variables" is based on those parameters which minimal change causes biggest impact on key indicators of effectiveness;
- method "triple calculation" is based on modeling of optimistic, probable and pessimistic scenarios of project implementation.

First two methods are linked with analysis of minimal changes of input and output parameters and give representative results only in case of high accuracy of initial information. Since, in our case this requirement almost can't be met, we apply on method of "triple calculation" with the following basic initial preconditions:

Optimistic option

- measures under consideration are realized during 3 years since 2005 till 2007;
- last year of project realization is a year of economic effect receiving (damage prevention) in amount of 40% from expected annual output (15,9 mln.USD). During next 3 years this effect will increase up to 60%, 80% and 100%, respectively,.

Probable option

- measures are realized during 5 years since 2005 till 2009 (second assumption is kept);

Pessimistic option

- due to lack of funding, measures are postponed on 3 years and then realized during 5 years since 2008 till 2012 (second assumption is kept).

Time since 2005 till 2020 is taken for calculation period. Года. Option of measures non realizing is taken as background. Data necessary to assess measures effectiveness are presented in tables 2-4. Taking into account high social meaning of the project discount rate is taken equal to 3%.

Table 9.1
Data for definition of net discount profit and payback terms over options (mln. USD)

Years	Background	Optimistic scenario			Probable scenario			Pessimistic scenario		
	damage	investments	damage	effect	investments	damage	effect	investments	damage	effect
2005	51,99	17,0	51,99	-	10,0	51,99	-	-	51,99	-
2006	51,99	17,0	51,99	-	10,0	51,99	-	-	51,99	-
2007	51,99	17,09	45,63	6,36	10,0	51,99	-	-	51,99	-
2008	51,99	-	42,45	9,54	10,0	51,99	-	10,0	51,99	-
2009	51,99	-	39,27	12,72	11,09	45,63	6,36	10,0	51,99	-
2010	51,99	-	**36,09**	**15,9**	-	42,45	9,54	10,0	51,99	-
2011	51,99	-	**36,09**	**15,9**	-	39,27	12,72	10,0	51,99	-
2012	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	11,09	45,63	6,36
2013	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	42,45	9,54
2014	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	39,27	12,72
2015	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2016	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2017	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2018	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2019	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2020	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2021	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2022	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2023	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2024	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**
2025	51,99	-	**36,09**	**15,9**	-	**36,09**	**15,9**	-	**36,09**	**15,9**

Table 9.2
Investments efficiency according to optimistic scenario, mln. USD

Years	Discount	Total result		
	factor	By year “t”	discounted	incremental
2005	1,0	-17,0	-17,0	-17,0
2006	0,971	-17,0	-16,51	-33,51
2007	0,942	-10,73	-10,11	-43,62
2008	0,915	9,54	8,73	-34,89
2009	0,888	12,72	11,3	-23,59
2010	0,863	15,9	13,72	-9,87
2011	0,837	15,9	13,31	3,44
2012	0,813	15,9	12,93	16,37
2013	0,789	15,9	12,55	28,92
2014	0,766	15,9	12,18	41,1
2015	0,744	15,9	11,83	52,93
2016	0,722	15,9	11,48	64,41
2017	0,701	15,9	11,15	75,56
2018	0,681	15,9	10,83	86,39
2019	0,661	15,9	10,51	96,9
2020	0,642	15,9	10,21	107,11

Table 9.3
Investments efficiency according to probable scenario, mln.USD

Years	Discount factor	Capital investments	Expected effect	Non-prevented damage compared with optimistic scenario	Total result	Discounted result	Incremental
2005	1,0	10,0	-	-	-10,0	-10,0	-10,0
2006	0,971	10,0	-	-	-10,0	-9,71	-19,71
2007	0,942	10,0	-	6,36	-16,36	-15,41	-35,12
2008	0,915	10,0	-	9,54	-19,54	-17,88	-53,0
2009	0,888	11,09	6,36	6,36	-11,09	-9,85	-62,85
2010	0,863	-	9,54	6,36	3,18	2,74	-60,11
2011	0,837	-	12,72	3,18	9,54	7,98	-52,13
2012	0,813	-	15,9	-	15,9	12,93	-39,21
2013	0,789	-	15,9	-	15,9	12,55	-22,66
2014	0,766	-	15,9	-	15,9	12,18	-14,48
2015	0,744	-	15,9	-	15,9	11,83	-2,65
2016	0,722	-	15,9	-	15,9	11,48	9,33
2017	0,701	-	15,9	-	15,9	11,15	20,48
2018	0,681	-	15,9	-	15,9	10,83	31,31
2019	0,661	-	15,9	-	15,9	10,51	41,82
2020	0,642	-	15,9	-	15,9	10,21	52,03

Table 9.4
Investments efficiency according to pessimistic scenario, mln.USD

Years	Discount factor	Capital investments	Expected effect	Non-prevented damage compared with optimistic scenario	Total result	Discounted result	Incremental
2005	1,0	-	-	-	-	-	-
2006	0,971	-	-	-	-	-	-
2007	0,942	-	-	6,36	-6,36	-5,99	-5,99
2008	0,915	10,0	-	9,54	-19,54	-17,88	-23,87
2009	0,888	10,0	-	12,72	-22,72	-20,18	-44,05
2010	0,863	10,0	-	15,9	-25,9	-22,35	-66,4
2011	0,837	10,0	-	15,9	-25,9	-21,68	-88,08
2012	0,813	11,09	6,36	9,54	-14,27	-11,6	-99,68
2013	0,789	-	9,54	6,36	3,18	2,5	-97,18
2014	0,766	-	12,72	3,18	9,54	7,31	-89,87
2015	0,744	-	15,9	-	15,9	11,83	-78,04
2016	0,722	-	15,9	-	15,9	11,48	-66,56
2017	0,701	-	15,9	-	15,9	11,15	55,41
2018	0,681	-	15,9	-	15,9	10,83	-44,58
2019	0,661	-	15,9	-	15,9	10,51	-34,07
2020	0,642	-	15,9	-	15,9	10,21	-23,86

Comparative assessment according to optimistic, probable and pessimistic scenario is presented in table 9.5 and 9.6.

Table 9.5
Definition of net discount profit and payback terms over options (scenarios)

Indicators	Scenarios		
	optimistic	probable	pessimistic
1.Net discount profit, mln.$	107.1	55.0	-23.9
2. Payback term, year	7	12	-

Table 9.6
Dynamics of total results over options (NDP, mln.$)

Scenarios	Years		
	2010	2015	2020
1. Optimistic	-9,9	52,9	107,1
2. Probable	-60,4	-2,65	52,0
3. Pessimistic	-66,4	-78,4	-23,9

Thus, following conclusions can be made from above data:

1. Effectiveness of measures on regulated water bodies creation in Syrdarya delta and Aral dried seabed is very sensitive to time of their realization.

2. Maximum effect can be achieved if work would be started as soon as possible and in case of the shortest time of its fulfillment. Integral effect according to optimistic scenario two times higher compared with probable one. As to pessimistic scenario, compared with optimistic one it gives negative result.

It worth to note, that high effect values in optimistic and probable scenarios is predetermined by using social discount norm. Its definition is linked with consensus achieving, which results influence net discount profit and payback terms.

It is confirmed by calculations according to optimistic and probable scenarios assuming that discount rate will be 7% (calculated is 3%). These results are presented in table 9.7.

Table 9.7
Effectiveness of measures under discount rate 7%

Years		Optimistic scenario			Probable scenario		
	Dis-count factor	Total result	The same discounted	Incremental	Total result	The same discounted	Incre-mental
2005	1,0	-17,0	-17,0	-17,0	-10,0	-10,0	-10,0
2006	0,935	-17,0	-15,9	-32,9	-10,0	-9,35	-19,35
2007	0,873	-10,73	-9,37	-42,27	-16,36	-14,28	-33,63
2008	0,816	9,54	7,78	-34,49	-19,54	-15,94	-49,57
2009	0,763	12,72	9,71	-24,78	-11,09	-9,0	-58,57
2010	0,713	15,9	11,34	-13,44	3,18	2,27	-56,3
2011	0,666	15,9	10,59	-2,85	9,54	6,35	-49,95
2012	0,623	15,9	9,91	7,06	15,9	9,91	-40,04
2013	0,582	15,9	9,25	16,31	15,9	9,25	-30,79
2014	0,544	15,9	8,65	24,96	15,9	8,65	-22,14
2015	0,508	15,9	8,08	33,04	15,9	8,08	-14,06
2016	0,475	15,9	7,55	40,59	15,9	7,55	-6,51
2017	0,444	15,9	7,06	47,65	15,9	7,06	0,55
2018	0,415	15,9	6,6	54,25	15,9	6,6	7,15
2019	0,388	15,9	6,17	60,42	15,9	6,17	13,32
2020	0,362	15,9	5,76	66,18	15,9	5,76	19,08

Results show effectiveness of measures on regulated water bodies creation in Syrdarya delta and Aral dried seabed. It is necessary to take into account high sensitivity of effectiveness indicators to time discount rate and payback terms. That’s why, it is necessary within short period to consolidate required financial resource and achieve consensus with investors about profit rate taking into account high social meaning of ecological issues solution.

X. CONCLUSION

In result of two projects INTAS RFBR-1733 and INTAS Aral -2000 1059 implementation, social-ecologic damage has been assessed. Losses and their evaluation for Priaralie in amount of 160,63 mln USD/yr has been done.

Factors causing natural complex degradation are following:

- inflow to delta and the sea reduction and induced by this desertification;
- ground water table lowering;
- autonomous ground water regime formation;
- ground water salinity increase;
- desertification – Aeolian processes, salt and dust transport.

Current changes have been analyzed:

- in soil-natural complex (soil maps of Priaralie);
- vegetation cover of Priaralie (tugai forests);
- natural and artificial landscape productivity decrease;
- birds population;
- fish productivity.

For situation stabilization set of measures are planned and carried out both for Northern and South Priaralie as well as for the sea itself.

In South Priaralie system of regulated water bodies for various consumers is designed and implemented. In north part of the Aral sea Small sea dam and other hydraulic structures funded by the World Bank and the Government of Kazakhstan are being constructed.

Analysis of these measures shows that they do not fully meet environmental requirements. In this connection, it is necessary to carry out design and construction (additional) and reconstruction of hydraulic structures in order this system will be ecologically and social-economically sustainable. Additional measures suggested by us are estimated in 900mln.USD for South Priaralie and 120mln.USDfor Northern Priaralie.

Project showed that though economic effectiveness of these measures is low, but they are ecologically and social-economically meaningful.

Taking into account high sensitivity of effectiveness indicators to time factor and discount rate, it is expediently consolidate needed financial resource in short time and achieve consensus with investors on investments' revenue rate with regard o high social and economic meaningfulness of natural disaster issues solution. Discount rate should be taken less than 2-2.5 %.

These measures will give opportunity to approach to indicators of development by 60-es of last century.

Main issue of future Priaralie social-economic development is coordinating between riparian countries ecological water requirements during different humidity years.

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