DYNAMICS OF A SOIL COVER OF KAZAKHSTAN PRIARALIE AND SYRDARYA RIVER LOWER REACHES

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For the last 20 years Aral Sea Region draws the attention of not only Kazakhstan scientists, but also experts of the different countries of the world. It is connected to catastrophic Aral Sea level decrease, development of desertification processes, and that standard of living of the population got worse. Typical feature of Aral Sea region desertification is aeolian and hydrogenic salinization of lands. On the dried sea bottom there is a formation of new natural complexes of desert type.

Reduction of Syrdarya River flow and absence of incoming fresh waters has resulted in amplification of drying up of the territories, disappearance of lakes, decrease of ground water level and increase of mineralization of the river, ground and sea waters. In recent years the type chemism of river water in a lower reaches of Syrdarya River has changed into sulphate-sodium instead of hydro-carbonate-calcium has changed. In ion structure of river water salts the quantity of chlorine increased that worsens its irrigation qualities.

The soil cover of the region suffered considerable changes. Many non-saline soils became into saline and the area occupied by solonchaks was increased. Practically there are no unsalinized soils on this territory at present. Desertification is accompanied by a decrease in fertility of hydromorphic soils. Humus decreased by 30-35% in 50-cm layer of meadow and swamp soils (Akhanov and Karazhanov, 1998). As a result, the nitrogen level also decreased (Nekrasova, 1979).

Drying up of the Aral Sea has resulted in an exposure of its bottom where soils begin to be formed. Studying soils' various stages of drying up allows to learn the process of formation and development of soils from a zero point, to understand the genesis of soils, and to reveal features of soil formation in a desert zone.

Depending on granulometric compound of adjournment and relief of the sea bottom it is possible to observe several types of soil transformation.

On sandy grounds the following evolution of soil cover is observed: marsh solonchaks > seaside primitive soils > seaside primitive soils with blown sandy cover > sands. On clay grounds soils develop through the following stages: marsh solonchaks > seaside solonchaks > solonchaks common > solonchaks takyr-like > takyr-like soils. The presence of negative relief elements marsh solonchaks transform to shor solonchaks with the time (Karazhanov, K. and A. Haibullin, 2001).

The main task of the soil researches which were carried out within the framework of the project INTAS 1072 was an authentic estimation of soil cover transformation for the period 1987-2003 years.

In result soil maps of Kazakhstan Priaralie and Syrdarya River lower reaches, in the environment of Geo-Information system in Maplnfo Professional, were constructed on the basis of field researches of 2003-2004 and use of “Landsat” and "SPOT" space image geographically adhered on raster with tool accuracy of several pixels.

Maps cover territory within Syrdarya River valley, modern and ancient Syrdarya River deltas, its floodlands, the territory of dried up Aral Sea bed, and also territories with irrigational systems, soils and landscapes of which have been exposed to the greatest anthropogenous transformation connected with agricultural activity.

The map of 1987 was made on the basis of the retrospective data and satellite images “Landsat” 1987. Map of 2003 - on the basis of the data of field researches and satellite images “SPOT” 2003.

1987 was an average on water level and water surfaces on satellite image coincides with the ones on topographical map. 2003 was abounding in water and water surfaces on a satellite image occupy the significant areas, covering soils.

Soils cannot instantly transform, thus they remain the same soils but flooded. Therefore the water surfaces correspond to a topographical basis for map of 2003.

Both maps include contour databases containing up to three soil types with their area characteristics and data on structure of soil cover and its distribution by forms of relief. Besides, databases contain codes of different types of landscapes, necessary for calculation of climatic parameters, the area of contours, Russian and English names of soils.

Maps allowing to observe the transformation of a soil cover of characterized territory are presented in figures 1 and 2.

During its preparation zonality of soils was essentially specified and the structure of soil cover is shown. Various soil combinations, describing the diversity of soil cover caused by conditions of soil formation

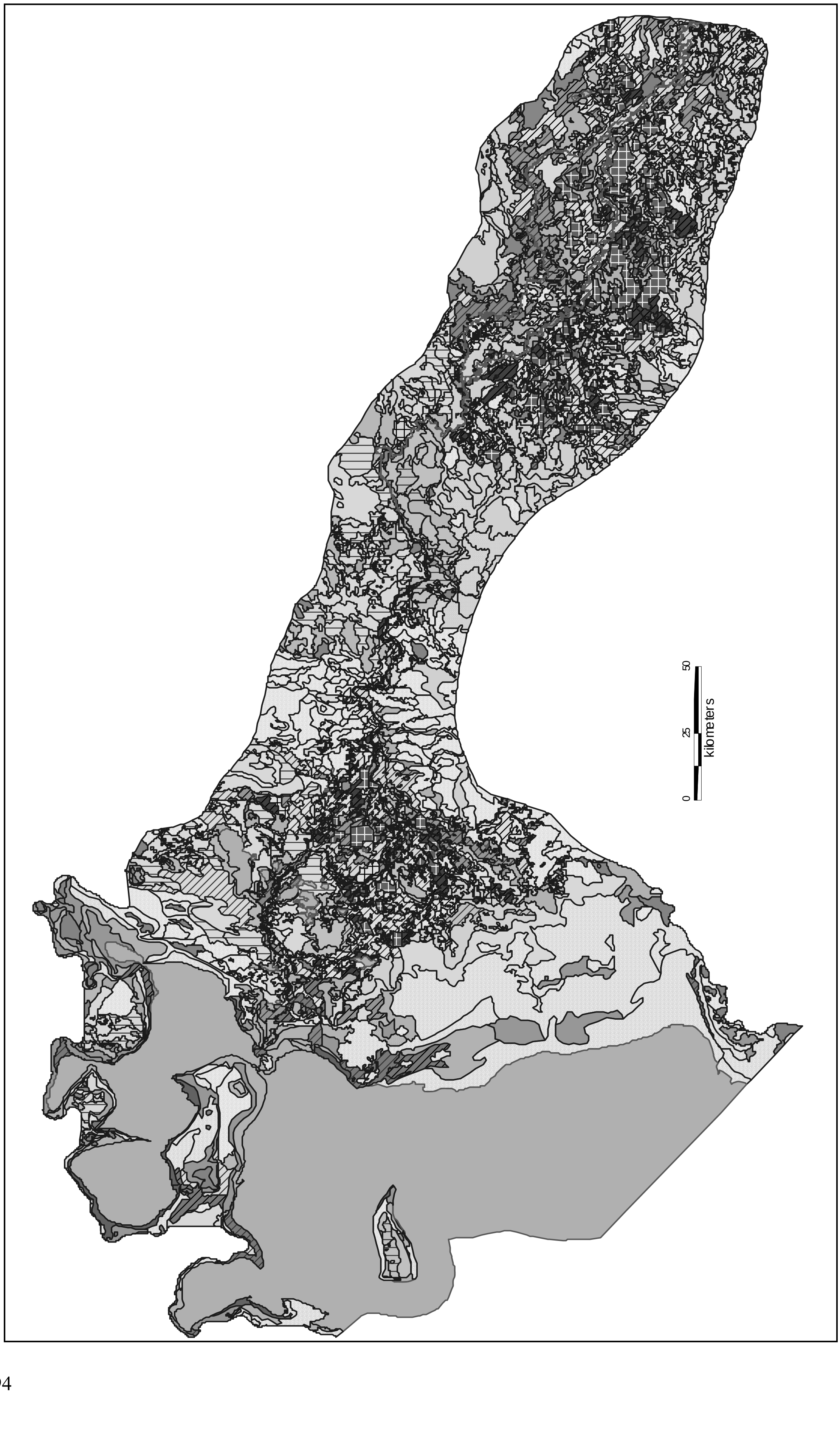

Figure 1. Soil map of Kazakhstan Priaralie and Syrdarya River lower reaches in 1987.

Figure 2. Soil map of Kazakhstan Priaralie and Syrdarya River lower reaches in 2003.

Soil maps legend

1 Brown desert non-salt soils	26 Alluvial meadowswampy dried salty soils
2 Brown desert salty soils	27 Swampy salty soils
3 Brown desert solonetzic soils	28 Swampy salty dried soils
4 Brown desert undeveloped soils	29 Alluvial swampy soils
5 Brown desert irrigated soils	30 Swampy salty soils
6 Graybrown desert nonsalt soils	31 Seaside swampy soils
7 Gray-brown desert salty soils	32 Seaside swampy dried soils
8 Gray-brown desert solonetzic soils	33 Desert solonetz
9 Meadow-brown soils	34 Usual solonchak
10 Takyrlike soils	35 Meadow solonchak
11 Takyrlike soil swith sand cover	36 Shor solonchak
12 Takyrlike irrigated soils	37 Secondary solonchak
13 Takyr	38 Takyric solonchak
14 Seaside soils	39 Seaside solonchak
15 Seaside soils with sand cover	40 March solonchak
16 Meadow salty soils	41 Desert hilly sands
17 Meadow dried salty soils	42 Desert ridge-hilly sands
18 Meadow irrigated soils	43 Desert eroded sands
19 Alluvial-meadow salty soils	44 Desert flat sands
20 Alluvial-meadow dried salty soils	45 Seaside salty sands
21 Alluvial forest-meadow soils	46 Rice-swampy soils
22 Alluvial forest-meadow dried soils	47 Anthropogenic-broken soils (settlement)
23 Meadow-swampy salty soils	48 Paleogenous and neogenoys parent material
24 Meadow-swampy dried salty soils	49 Water
25 Alluvial meadowswampy soils	50 Anthropogenic-broken soils (towns)

with relief, mother rocks, ground waters, vegetation, anthropogenous influences are allocated. The basic types and subtypes of soils are shown in the map. Soil genera, differing on carbonate compound, salinization level and other attributes, caused by influence of soil forming rocks, ground waters etc. are allocated among them.

Results of soils analytical research and generalization of the retrospective data have allowed to characterize the basic morphogenic properties of soils allocated on maps. They are resulted below.

Brown desert soils are a zone subtype of a subzone of northern deserts. Soils are formed in authomorphic conditions on watershed surfaces of smoothed hilloks and ridges and also are occured as homogeneous contours on the sandy and loamy-sandy plains adjoining or located among sand masiffs.

Water regime of soils is not flushing; their humidifying occurs only due to atmospheric precipitation. Thereof brown desert soils are carbonated on surface, oftenly they feature by residual alkalinity and salinization. Within the limits of characterized territory brown desert soils are presented by genera of not salinized, salinized and solonetzic.

Brown desert not salinized soils form large quite homogeneous contours on flat and slighly rolling sandy plains. In conditions of more brocken relief brown normal soils are located on mezo- and microrelief increases of light texture. They are formed in conditions of good drainage basically under rarefied diverse-wormwood vegetation at insignificant participation of ephemers and ephemeroids.

The soil profile is characterized by weak differenciation of genetic horizons by color: from grayish-light-brown accumulative-humus horizons up to yellowish-light-brown of underlaying sands. Surface (0-2 cm) - crust followed by little bit schistous, cloddy-powder-like horizon, frequently with fine roots (A2=7-8 cm). Below - brown lumpy illuvial-humus horizon (B), has more dense structure and followed by carbonated horizon which has light-pale-yellow color with spots of carbonates, and underlayed by unstructured sandy or loamy-sandy rocks.

Brown desert normal soils of characterized territory contain up to 2,5-5 % $_{\text{of } CO_2}$, poor in organic substance (its content does not exceed 0,5-1,0 %). The content of total nitrogen is 0,02-0,06%. Rather small content of silt fractions and humus causes low capacity of absorption (6-15 mg-equ/100 g of soil). Reaction of soil suspension alkalescent and alkaline, with gradual increase of alkalinity with depth up to pH=9. Soils with light (loamy-sandy) texture prevail.

Brown desert salinized soils are similar with brown desert not salinized soils by morphological structure and the basic physical and chemical properties, differing by presence of watrsoluble salts in a profile. The sum of salts from depth 50-60 cm reaches 0,7 % at sulphatic type of salinization on anions, and calcius one on cations with increase in salt amount with depth.

Brown desert solonetzic soils form homogeneous contours in some places, but mostly lie in a complex with desert solonetz. The vegetation cover of brown desert solonetzic soils is represented mainly by anabasis-wormwood associations with various share of ephemers and salsolas participation.

Soils unlike normal are characterized by presence of dark-colored illuvial-solonetzic horizon B in an average part of profile or the bottom part of humus horizon. It is characterized by firm consistence, cracking, nutty structure.

Brown desert solonetzic soils contain 0.7-1.5 % of humus, 0.05-0.1 % of total nitrogen. The capacity of absorption makes about 10-15 mg-equ./100 g of soil with a maximum in solonetzic horizons. The absorbed bases are presented mainly by calcium, alongside with it the essential role is played by sodium which amount can increase up to 20 % with depth . Reaction of soil solution is alkaline, amplifying in solonetzic horizon. Not deep deposit of the readily soluble salts presented mainly by sulfates of calcium is characteristic for brown solonetzic soils. The sum of salts of horizon of 60-80 cm reaches 0,5-1,5 %. The texture of soil changes from loamy-sandy on surface up to heavy-loamy, sometimes clay solonetzic horizons.

Brown desert undeveloped soils are formed in conditions of strongly brocken relief on low-thickness loamy-crushed stone elluvium of bedrocks and are located mainly on benches. Soils have truncated, strongly stony profile. Thickness of soil profile does not exceed, as a rule, 15-30 cm. More dark horizon, quite unclearly, is allocated in its top part. Sometimes the whole profile consists of horizon A, directly transfoming to marl of bedrocks.

Gray-brown desert soils are a zone soil subtype of desert zone, a subzone of central deserts. Genetic features of gray-brown desert soils, caused by arid bioclimatic conditions and properties of soil forming rocks, are low thickness of a soil profile, the low content of humus, significant accumulation of carbonates with a maximum in the top horizon, the high contents of gypsum on small depth.

Within the limits of the surveyed territory gray-brown desert soils are presented by genera not salinized, salinized and solonetzic.

Gray-brown desert not salinized soils form large enough homogeneous contours on flat and slightly rolling watershed surfaces; on flat slopes of ridges and the lowered sites of a relief lie in a complex and a combination with desert solonetz and gray-brown solonetzic soils. The vegetation cover is presented mainly by wormwood-salsola associations with insignificant participation of ephemers.

The profile of gray-brown normal soils is quite precisely differentiated on genetic horizons. Presence of pale-grey porous crust (2-5 cm), broken by cracks, with schistous loose light grey subcrustal horizon with thickness of 7-10 cm lying under, is typical for it in the top part. Average part of profile (horizon B) differs appreciable density and brown hue, large-cloddy, sometimes lumpy structure, eye-spot carbonates. Gypsum in the form of veins and druse-like congestions in the bottom part of profile is not rare.

Gray-brown desert soils are very poor with humus which content does not exceed 0,8-1 %. The sum of the exchange bases hardly reaches 10 mg-equ/100 g of soil from which 85-90 % are calcium, 10-12 % - magnesium and 1-3 % - sodium and potassium. High content of carbonates (up to 9-10 % CO_2 in superficial horizons), a little bit decreasing with depth, is characteristic for soils. Soils are characterized by alkaline reaction of a soil solution, pH water suspension changes within the limits of 7,5-8. The content of gypsum in the bottom part of a profile can reach 30 %. Light-loamy prevail in texture, at appreciable heavy texture in an average and bottom part of a profile .

Gray-brown desert saltinized soils are characterized by allocation of water-soluble salts in under-humus part of a profile (about 30-40 cm). Salinization is mainly of chloride-sulphatic type (on cation content - calcium-sodium).

Gray-brown solonetzic soils are developed mainly under wormwood-anabasis, wormood-salsola orientalis-anabasis vegetation and occupy the leveled surfaces of relief where form big homogeneous contours, or form complexes and combinations with takyrs and solonetzs. Dark-brown illuvial solonetzic horizon B is characteristic for the profile. It differs significant density, cloddy or lumpy structure, heavier texture. It is observed salinization; spots and eyes of carbonates from depth of 30-40 cm . Humus part of a profile (A+B) varies within the limits of 25-30 cm.

Gray-brown desert solonetzic soils are poor with humus (0,7-0,9 %). Capacity of absorption on sharply increases in solonetzic horizons in 2-3 times, at increase in share of sodium up to 15-20 % from the sum of the absorbed bases. Illuvial solonetzic horizons are characterized with heavier texture with increase of the content of silt fraction in 3-4 times.

Meadow-brown soils are semi-hydromorphic and are widespread within the limits of delta-alluvial plains, lying on the lowered sites of a surface, the broad gullies, the dried up river beds, low flood plain terraces. These soils are formed in conditions of the additional capillary-soil humidifying caused by close level of underground waters to surface (3-5m). High mineralization of underground waters causes salinization of soil profile. Mezophyte associations prevail in a vegetation cover of meado-brown soils.

Meadow-brown salinized soils in comparison with zone desert soils contain noticeably more humus and nitrogen (up to 1,5-2,3 % and 0,07-0,17 % accordingly). The sum of the absorbed bases varies significantly: in adjournment of light texture it makes 9-14, and in heavy texture reaches 20-30 мг-equ/100 g of soil. The absorbed complex is saturated basically by calcium. The contents of carbonates reaches 6-8 $\%_{CO2}$. Reaction of soil suspensions alkaline, with some increase of alkalinity with depth. Meadow-brown soils are characterized by a various degree of salinization of sulfate-chloride type. The content of soluble salts makes 0,5-2,0 %. Sodium prevails as cation. Soils are, as a rule, non-homogenous and layered in texture.

Desert solonetzs are widespread within the limits of characterized territory and lie as continuous masiffs, and also as forming various combinations with other soils. In a vegetation cover black wormwood and anabasis with rare participation of ephemers and practically universal - lichens prevail.

Desrt solonetz contain little humus (0,8-1,0 %) and nitrogen (0,03-0,07 %). The sum of the absorbed bases in over-solonetzic horizons low - 8-10 mg-equ/100 g of soil, increasing in solonetzic up to 20-25 mg-equ/100 g of soil. The content of the absorbed sodium in solonetzic horizons reaches 25-35 %. Reaction of a soil solution alkaline (pH=7,5-8,5), with increase of alkalinity in solonetzic horizon that is connected with the high content of the absorbed sodium.

Eluvial horizons are light-loamy. Illuvial horizons are heavy-loamy with high quantity of silt particles. Soils are not salinized from surface, lightly salinized in horizon B, and salt amount of salt increases up to 1.5 % below solonetzic horizon.

Takyr-like soils are formed in conditions autho-morphic water regime under the rarefied vegetation on layered quanterary alluvial deposits of ancient delta plains of Syrdarya river and occupy extensive flat surfaces, or lying among hillok sand massiffs, under rarefied vegetation presented by saxaul, wormwood, anabasis, salsola.

Soils are characterized by hard porous crust broken by vertical cracks (A=7cm).

Takyr-like not salinized soils are poor with organic substance. The content of humus from a surface does not exceed 1 %. Distribution of humus is non-uniform in profile, that is connected with ancient alluvial genesis of characterized soils and presence of burried horizons. The content of total nitrogen also is insignificant (0,06-0,10 %), its maximum corresponds to horizons with the greatest humus content.

Takyr-like soils with blown sandy cover are formed on border of sandy massifs and in inter-range downturns under rare salsola orientalis and wormwoods. The sand cover has thickness of 10-50 cm, the below profile is mainly loamy. Favourable conditions of humidifying due to formation of sandy cover cause disappearance of crust. Maximum of salts (up to 2,5 %) is on depth 60-200 cm. Salinization is chloride-sulfate. The content of humus up to 0,4-0,6 %, its maximum quantity is in blown horizons where the greatest amount of roots is concentrated.

Takyrs are formed on negative elements of a relief - the closed depressions and negative elements of relief of various sizes (from several square meters up to several kilometers), accumulating atmospheric precipitation, fine silt mineral substances and soluble salts, washed out from surrounding higher surfaces. It is characterized by presence of very dense porous crust (1-2 cm) with the smooth matte surface broken into polygonal separateness, underlayed by lamellar horizon with thickness from 10-15 till 20-25 cm.

Soils are carbonated from surface; content of $_{CO2}$ in carbonates changes from 2-3 up to 8-10 %. Takyrs contain insignificant amount of humus (0,4-0,5 %). Reaction of soil suspension alkaline. The sum absorbed cations low (7-8 mg/equ/100 g of soil). The content of soluble salts reaches 0,7-0,9 %, they are presented mainly by bicarbonates Na and K at significant prevalence of sodium salts. Mechanical composition is clay.

Seaside primitive salinized soils have a wide circulation within the limits of the dried bottom of Aral sea. Their formation is connected with initial stages of soil formation in a mode salts washeing out, caused by light mechanical composition of the top horizons and lowering level of underground waters. A vegetation cover is non-uniform, basically presented by psammaphytes with appreciable participation of halophytes, on downturns with reed, aeloropis litoralis and others mezophytes cereals which share is insignificant.

Seaside primitive soils differ practically by not formed profile; they have no developed humus horizon. From a surface they are combined by draft-sandy-shelly deposits, from depth in 30-60 cm their profile is, as a rule, layered, variegated colored, with attributes of residual and modern gleying. From a surface - not salinized, visible allocation of salts in the form of specks and veins are marked from depth of 15 cm.

Distinctive feature of all seaside primitive soils is their high degree of salinization. The sum of salts in a sady-shelly layer (0-10-15 sm) does not exceed one percent, but the amount of salts sharply increases up to 1-2 % with depth. Type of salinization, as a rule, sulfate-chloride-sodium. Described soil contain low amount of humus upt to 0,5 %.

Seaside primitive soil with blown sandy cover are formed under very poor halophyte-psammophyte vegetation on sites of the seaside plain, adjoining to seaside sand massiffs. Thickness of blown layer can change in significant limits (10-70 cm), it differs by absence of attributes of soil formed processes, friable and schistous by consistence, is not salinized. Profile structure corresponds to those at seaside primitive soils without a sand cover with depth.

Meadow salinized soils are formed on downturns with close level of mineralized underground waters (1,5-3). The vegetation is presented by meadow associations with smaller or greater participation of halophytes.

Meadow soils are formed in conditions of unstable mode of humidifying and differ weakly formed profile, which is characterized by cleavage and presence of burried horizons. Morphological and physical and chemical properties of soils reflect both attributes of previous stages of development, and the features determined by modern soil forming processes, and differ by wide variability.

The content of humus and nitrogen, as a rule, does not exceed 2,5 % and 0,17 % accordingly. The sum of the absorbed bases makes 10-13 mg-equ/100 g of soil. Soils are high carbonated - 5-15 $\%_{CaCO3}$. The sum of salts reaches 1-1,5 % and more. Type of salinization mainly sulphatic and chloride-sulphatic.

Formation of *meadow drying salinized soils* is connected with level decrease of underground waters and change of soil forming process to a zone type. Meadow cereals drop out of structure of vegetation and are replaced by halophyte and xerophyte grasses, that leads to destruction of sod horizon with formation broken by cracks crust on a surface. In the rest morphological structure of soils long time keeps attributes of a meadow stage of development. Changes in chemical properties of soils are connected first of all with decrease of humus in superficial horizons (up to 0,7-1,5 %) and displacement of a salt maximum from a surface on depth of 15-25 cm at increase in the content of salts.

Alluvial meadow soils are a dominating element of a soil cover of alluvial and low high water bed terraces of Syrdarya river. Underground waters lie on depth of 2-4 m. With the distance from Syrdarya river and decrease in level of underground waters characterized soils are replaced by alluvial meadow drying soils. The vegetation cover is presented by shrub thrickets with the rarefied grass-cereal vegetation.

Now alluvial-meadow soils are not flooded during high waters, and soils get mainly capillary-soil humidifying, and only incidentally - additional superficial one.

For a morphological structure alluvial meadow soils it is characteristic: a grey shade of the top horizon, clevage of the whole profile, frequently presence of soluble salts in medium or superficial horizons , attributes of gleying in the form of glaucescent tones of soil thickness and rusty spots in the bottom part of profile, and also presence of burried humus horizons.

Degree of soils salinizatiom is various - from not salinized up to solonchaks, with more than 1 % of salts with sulfates prevail. The maximum of salts is usually in superficial horizons.

Soils are layered by mechanical structure. Clay prolayers lie from a surface, as a rule, the light layer on mechanical structure is marked further.

Alluvial meadow drying soil are formed under rarefied salsola-grass (weeds) vegetation with participation of trees and bushes. They form combinations with alluvial meadow soils, being formed under more raised forms of a relief, or form extensive homogeneous contours on suburb parts of flood delta and Syrdarya river bed. Humus coloring of the top horizons is usually poorly appreciable. The morphological shape of the bottom and medium part of profile corresponds to that of alluvial-meadow soils.

Owing to weak sod vegetation accumulating-humus horizon is noticeably schistous, practically without roots, friable consistence and rough lumpy structure. Lying below horizon B is more dense, brown color. The structure of a profile is typical for alluvial soil in deeper horizons. Allocation of small-crystallic salts and numerous ochre spots of iron oxide are observed from 10-15 cm. Visible allocation of carbonates are absent.

The contents of humus varies over a wide range (0,5-2,5 %), as well as capacity of absorption (15-30 mg-equ/100 g of soil) depending on a stage of drying. The soil complex is saturated basically with calcium (up to 70-75 % from the sum of the absorbed bases), partly magnesium. Alluvial meadow drying soil are characterized mainly by average (0,6 %) and sometimes strong (up to 1,5 %) degree of chloride-sulphatic salinization at a maximum in superficial horizons.

Alluvial forest-meadow soils are formed on near river bed banks of Syrdarya river under grass-shrub-wood vegetation and have the extremely insignificant distribution. The top horizon (up to 20 cm) of alluvial forest-meadow soils has dark grey color. From a surface the small sod horizon is allocated. By consistence soils are layered, mainly light mechanical composition. Burried horizons on different depth reflecting dynamism of alluvial processes are occured in profile. Traces of gleying are marked almost from a surface of profile.

The humus content in alluvial forest-meadow soils varies within the limits of 1,6-3,0 %. A degree of salinization of alluvial forest-meadow soils is various. Salts are usually concentrated in the top horizons (up to 0,7-0,8 %) at less salinized bottom (more deeply 50-80см) parts of profile. The sum of salts varies from 0,1 up to 1,5 %, with deviations on separate layers depending on their mechanical composition. Salinization chloride-sulphatic, with prevalence of sulfates over chlorides more, than five times.

Meadow-swampy and swampy salted soil lie depressions with very close subsoil waters under moisture-loving vegetation. On a morphological structure and chemical properties it noticeably differ, as the part from them is situated on drying up lakes, near the channels, former river-beds and former gulfs of Aral sea, and the part is formed in zones of flooding by waste waters of irrigational channels.

In general profile of this has well expressed, but truncated humus horizon (30-50 cm). Lower lie gleyed grey, sometimes spotty ochra-grey with insignificant content of humus horizon. Visible carbonates are absent. In the top part of profile can be observed krystals and spangles of the salts.

Soil are characterized by high enough contents of humus and nitrogen (3-4 % and 0,2 % accordingly), sharply decreasing with depth. As the capacity of absorption sharply decreases from 20-25 mg-equ/100 g on surface to 6-7 mg-equ in gley horizons. Soils possess significant cloride-sulphatic sodium salinisation in all profile (0,4-0,7 %). Reaction of water soil suspensions is alkaline.

Alluvial meadow-swampy and swampy salted soil have insignificant distribution owing to sharp reduction of freshet floods. In a high water underground water level lie on depth less than 1 m, during between high waters they fall up to 1,5-2,5 m, providing capillary humidifying of superficial horizons of soils and their solinisation. Profile are like to above described medow-swampy and swampy salted soils, differing strong lamination, presence buried horizons. The contents of humus and nitrogen fluctuate in significant limits (2-7 % and 0,1-0,5 % accordingly), with sharp reduction with depth. Content of carbonates usually high (up to 30 %), varying on horizons. Superficial horizons are noticeably salted (0,2-0,4 %). Reaction of soil suspensions is alkaline.

Meadow-swampy and swampy drying salted soil, including alluvial, long time is kept with attributes of previous stages of development though up to 2-5 m do not test soil humidifying. At dying off vegetation the surface of soil becomes bare, crast is forming. Change of periodically washing water regim to exudational leads to strong salinisation of profile. The maximum of salts is charactered for superficial horizons. Amount of the salts reach more then 2 %. Salinisation is cloride-sulphatic and sulphatic.

Solonchaks within the limits of characterized territory occured very widely, being formed on least drained areas representing the favorable environment for salt-accumulation due to ascending transit of a underground-capillary water and soluble salts due to intensive evaporation. A diagnostic parameter of solonchaks is strong salinity of profile from the surface (more than 1 %).

Meadow solonchaks are formed within the limits of flood areas of Syrdarya delta and, as a rule, do not form large homogeneous contours, but form complex with alluvial meadow soils and ordinary solonchaks. The basic vegetation formed by Tamarix and Aeloropis. The top horizons are coloredby humus, from a surface are saturated with salts and often loosened. Soils contain up to 2-5 % of salts in superficial horizons which quantity decreases with depth. Type of salinization - chloride-sulfate.

Common solonchaks are formed under mainly perennial salsola vegetation on surfaces with higher level, than meadow ones, in conditions of sharply expressed exudational mode at superficial level of mineralized underground waters. Surface of soil is chubby (up to 7 cm), hilly, with salt fragile crust of pale-light grey color. Underlaying horizons are motley, layered, humidified, with numerous vein form salts. Soil boil from a surface; reaction of a soil solution is alkaline. The maximum of the salts consisting mainly from chlorides, is at a surface (up to 2-5 %). The content of humus makes less than 1 %; capacity of absorption is low (8-12 mg/equ/100 g of soil).

Shor solonchaks occupy the closed depressions of the various sizes. Close level of strong mineralized underground waters provides high salinization of profile, interfering the development of vegetation. Shor solonchaks are poor in soil formation. The structure of profile is characterized by presence of small-crystallic salt crust, formed as a result of intensive summer evaporation of underground waters, moist viscous clay, sometimes sandy unstructured mass lies under it. Underground water is on depth less than 100 cm. Reaction of soil solution is alkaline. Visible allocation of salts is on the whole profile. A degree of salinization is high: crust contains up to 30-40 % of salts. Salinization is sulfate-chloride.

Secondary solonchaks are to some extent inevitable consequence of an irrigation in desert zone at cultivation of this soils, formed on salinized soil forming rocks. Especially big areas of secondary solonchaks are located on thrown rice checks and territories adjoining them. As a whole the external shape and character of distribution of salts on profile of secondary solonchaks is similar to those at ordinary solonchaks, especially in superficial horizons. Distinctive features are a little increased humus content, higher density of profile on depth of 20-40 cm, residual attributes of recent bogging.

Takyric solonchaks widespread in ancient delta plain of Syrdarya , also lie as homogeneous contours, and forming spots with brown desert salinized soils or complexes with solonetzs. Takyric solonchaks are formed under rarefied perennial salsola vegetation, sometimes with rare ephemers and annual salsolas. Morphological structure is characterized by sometimes dense, porous, schitose, broken on polygonal separateness, crust up to 4-5 cm thickness, lying from a surface and replaced by loose structures, horizon. As a whole the profile is characterized by lamination, presence of attributes of gleying, numerous salts from 15-20 cm. Humus horizon is poorly expressed, reaches 20-30 cm.

Superficial crust is not salinized (0,2-0,3 % of salts). Their amount sharply increases in subcrustal horizon up to 1-1,5 %, increases up to 2,5-3 % in medium part of profile with depth. In superficial horizons type of salinization is sulphatic, in medium and bottom part of profile - chloride-sulphatic.

Seaside solonchaks. Formation of these soils is connected with recent regression of Aral sea and initial stage of development of soil forming processes. Soils are formed at close level of highly mineralized underground waters to a surface (1-2,5) under the rarefied vegetation cover presented by annual salsola, ephemers-perennial salsola associations.

Seaside solonchaks are characterized by the humidified, layered, floridly colored profile with prevalence rather dirty-grey, dove-grey tones, from a surface having thin crust, sometimes with salts. Humus layer is poorly generated, its thickness does not exceed 15-25 cm. It frequently followed by layered salinized soil forming rock. Attributes of gleying are shown from depth at 20-30 cm.

Seaside solonchaks have strong degree of salinization of soils from a surface (more than 1 %), in medium part of profile (40-80 cm) the amount of salts increases up to 8 %. It basically sulfate-chloride solonchaks by type of salinization.

March solonchaks are formed in periodically flooded seaside strip. The vegetation generally is absent, or is presented by annual salsolas. The morphological structure of profile is characterized by humidification, strong lamination, absence of humus horizon, attributes of gleying are from a surface. As a whole on the basic chemical properties march solonchaks are close to seaside ones.

Sand within the limits of the mapped territory occupy the significant areas.

Hill and range-hill sands are a prevailing kind of sandy massiffs. On ancient alluvial plains sands have homogeneous structure and absence of salinization, basically fixed.

Flat sands border massiffs of hill sands, and also occupy flat-lowered sites of wide hollows, making transition from shor-solonchak depressions to hill sands. A surface of flat sands is almost flat. Sometimes poorly hilly sites and not deep superficial downturn occured.

Seaside salty sands are located on the sea shore, sometimes forming coastal shaft. Seaside sands are characterized by an abundance of inclusions of a cockleshell, a pebble, fragments of bedrocks, remains of sea flora, lamination. They differ by significant degree (more than 1-2 %) of chloride-sodium salinization from a surface though visible salts are not found out.

Formation *eroded sands* is connected with intensive anthropogenous influence both agricultural, and technogenic. The organic substance in loose sands is less than 0,3 %. The amount of carbonic acid in superficial thickness reaches 2,4-2,6 %. Loose sands consist basically of fine-grained sand. The contents of dust particles does not exceed 1 %.

Irrigated soils irrespective their type undergo the deep transformation caused, besides the mechanical and chemical influences connected with agrotechnical actions on processing of an arable land, change of a water regime with not percolative on percolative. For irrigated soils in comparison with virgin analogues it is characteristic less differentiated on color and mechanical structure dense profile with stretched humus horizon and clarified arable one. Losses of humus in arable horizon can reach 50-60 %, especially in the first years of an irrigation. In under-plough horizon, on the contrary, there is a relative increase in the content of humus.

At long-term irrigation of soils in bottom (under-plough) parts of profile mechanical composition is getting heavier, mainly due to silt fraction. The mechanical composition of arable horizon can essentially vary even within the limits of one field owing to appearance of the irrigational erosion causing increase of sandy fractions in the washed off zone, and clay and silt fractions - in accumulative.

Rice-marsh soils are formed in conditions of periodical flooding. Crops are developed on meadow, meadow-marsh, marsh, takyr-like soils. Duration of constant flooding of rice fields makes 90-110 days, up to 15 thousand m^3/hectares of water is filtered during this time through soil. As a result of it level of underground waters varies seasonally - from 2,5 m in the beginning of irrigation to levelling out with irrigating waters during vegetation of rice in autumn.

Due to regenerative processes in anaerobic environment there is a black layer on depth of 0,5-1,5 cm, containing sulphurous compounds (hydrogen sulphide, iron protoxide). Salt wash out occurs in an arable layer and increase in density of under-ploughed horizon, increases alkalinity of soil solution, the amount of humus decreases, and humus horizon is stretched. The rest basic chemical properties of rice-marsh soils are close to virgin marsh soils.

Soil maps and data on the main morphogenic properties of soils are necessary for revealing tendencies of change of soils and soil cover of the territory, and also for forecasting further transformation. For the given project, which has a social and economic orientation, it is very important to reveal and coordinate the transformation of the territory connected with natural and social and economic conditions.

One of possibilities for this is the relative evaluation of soils based on ball system (balls of bonitet), showing value of soils relative to each other and most fertile soils (in case of Kazakhstan chernozems). In this case the soil is evaluated on its natural fertility and includes key parameters of fertility - humus content, presence of exchange cations of sodium in an absorbing complex, level of salinization, extra moistening, stoniness, etc. (The collection of temporary methodical instructions according to lands, 1979).Balls of bonitet of soils for considered territory have been calculated by the technique accepted in Kazakhstan.

The maps of bonitet indexes on 1987 and 2003 are created on the basis soil maps. Soil maps contain up to three types of soils in each contour with their area characteristic, thus for the specific intervals weighted average balls of bonitet on area of soils have been calculated. Scale of bonitet indexes are shown on table 1 and maps of bonitet balls for 1987 and 2003 are presented on Fig. 3, 4.

For creation of more evident picture of the general tendencies of soils properties changes on the basis of two introduced maps the map of dynamics of a soil cover has been created (Fig. 5). On the base of this map it is possible to count up the general increase in value or damage of territory in standard units or in any currency.

For maintenance of sustanable development of territory following measures and activities are offered.

Measures on improvement of a condition of an irrigated arable lands:

For prevention of a secondary salinization and restoration of the salted soils - carrying out of washings with obligatory removal of drainage waters for borders of territory.

Agronomical practices for an arable land - increase in depth of plowing, change of water-physical properties and culturing of ploughland (increase in thickness of an arable layer, enrichment by organic substances), flat, subsoiling plowing and zero cultivation, strip disposition of a fallow and row crop, mulching.

Organizational-economic measures and restoration are recommended for the long-irrigated arable lands dated for natural complexes of an alluvial plain - realization of re-planning of rice fields, regular levelling of a surface of a field.

The differentiated application organic and mineral fertilizers in view of a degree of degradation of arable lands

Definition of an optimum ratio of the area of farmland and exclusion from a crop rotation of unprofitable arable lands

Leading of soil-protective and water-saving technologies of watering, its qualitative improvement, realization of antierosion watering technique, reconstruction of an old irrigating network with use of polythene pipes and concrete trays).

Protection and rational use of pastures and haymakings:

Temporary interdiction of a grazing on plots, are exposed strong degradation. Such degraded pastures are usually widespread near to villages, winterings, wells.

Measures on a flooding of pastures are recommended for all natural-territorial complexes where there are no water sources and provide reconstruction old and arrangement of new wells, chinks.

Selective hay-mowing is recommended within the limits of natural complexes of the alluvial plains, described a stable and satisfactory landscape-ecological condition in view of a season and agroclimatic conditions current year.

Table 1. Scale of bonitet indexes.

Soils	Index of bonitet
Meadow irrigated soils	8
Brown desert irrigated soils	5
Takyr-like irrigated soils	5
Alluval forest-meadow dried soils	5
Meadow-swampy dried salty soils	4
Brown desert non-salt soils	4
Meadow-brown soils	4
Meadow salty soils	4
Alluvial-meadow salty soils	4
Alluvial-meadow dried salty soils	4
Alluval forest-meadow soils	4
Meadow-swampy salty soils	4
Gray-brown desert non-salt soils	3
Rice-swampy soils	3
Meadow dried salty soils	3
Alluvial meadow-swampy soils	3
Alluvial meadow-swampy dried salty soils	3
Desert solonetz	3
Gray-brown desert solonetzic soils	2
Swampy salty dried soils	2
Takyr-like soil swith sand cover	2
Brown desert solonetzic soils	2
Brown desert undeveloped soils	2
Gray-brown desert salty soils	2
Alluvial swampy soils	2
Alluvial swampy dried salty soils	2
Desert flat sands	2
Takyr-like soils	2
Swampy salty soils	2
Brown desert salty soils	2
Takyr	1
Seaside soils	1
Seaside soils with sand cover	1
Seaside swampy soils	1
Seaside swampy dried soils	1
Meadow solonchak	1
Secondary solonchak	1
Seaside solonchak	1
Desert hilly sands	1
Desert ridge-hilly sands	1
Anthropogenic-broken soils (settlements)	1
Anthropogenic-broken soils(towns)	1
Takyric solonchak	1
Usual solonchak	1
Shor solonchak	0
March solonchak	0
Desert eroded sands	0
Seaside salty sands	0
Paleogenous and neogenoys parent material	0
Water	0

Fig. 3.. Map of of bonitet indexes on 1987.

Fig. 4.. Map of of bonitet indexes on 2003.

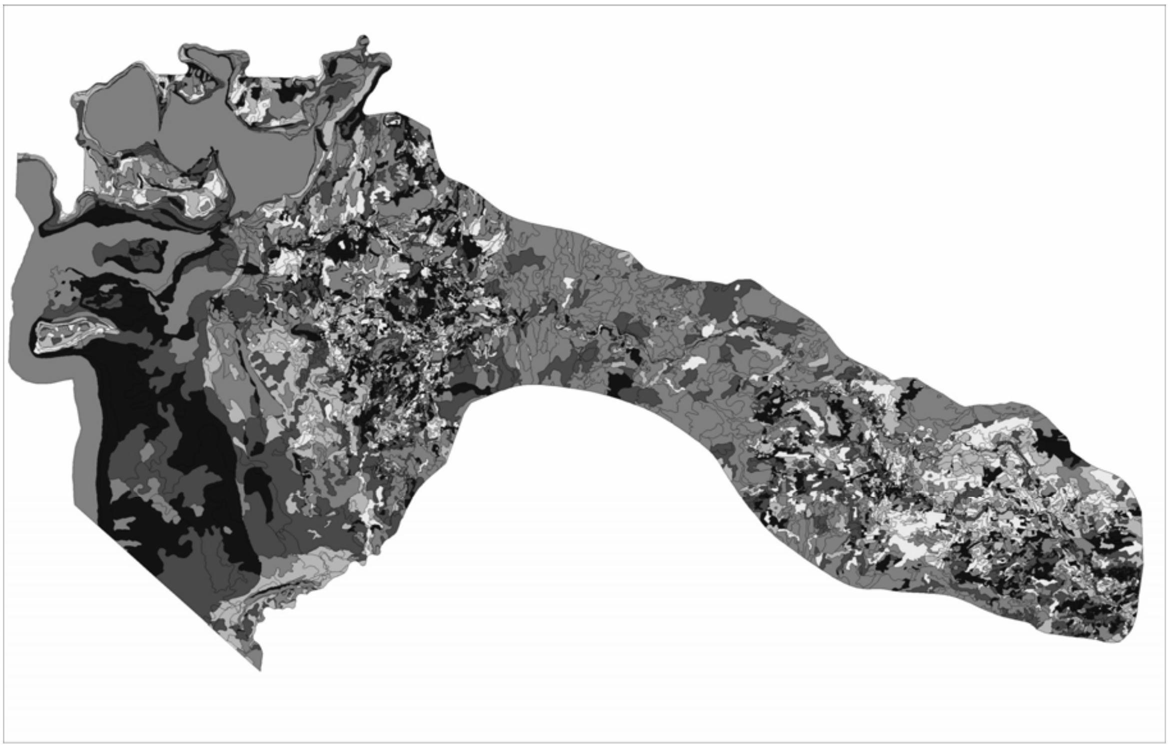

Fig. 5. Map of dynamics of a soil cover (grey color – not changed territories, light color – positive bonitet, dark color – degradation).

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Резюме

Пачикин К., Кривенко В., Ерохина О., Шильдебаева С. **Динамика почвенного покрова Казахстанского Приаралья и нижнего течения р. Сырдарья**

Прогрессирующее развитие процессов опустынивания в Приаральском регионе вызывает настоятельную необходимость достоверной оценки степени трансформации почвенного покрова в результате снижения уровня Аральского моря, зарегулирования стока реки Сыр-Дарьи и нерационального водопользования. Созданные с использованием космических изображений SPOT и Landsat и фактических данных, полученных во время полевых исследований, почвенные карты по состоянию на 1987 и 2003 год, с одной стороны, фиксируют изменения, произошедшие за этот период, а с другой, могут служить основой для составления прогнозных и других специальных карт, в качестве которых представлены карты бонитета почв и карта динамики почвенного покрова региона.