ASSESSMENT REPORTS ON EMERGING ECOLOGICAL ISSUES IN CENTRAL ASIA

Ashgabat, 2006

Foreword

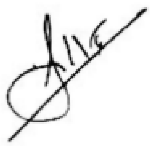
In December 2006, five Central Asian countries established the Environment Convention as an important initiative for regional co-operation among the member states on sustainable development. The implementation of the Convention requires regular assessment of the state of the environment with a focus on emerging environmental issues.

The United Nations Environment Programme (UNEP) is mandated to regularly assess and monitor major environmental challenges and trends. The rapid socio-economic growth coupled with increase in intensity and frequency of natural disasters have brought many challenging emerging issues to the forefront. The emerging environmental issues are a threat to food security, water security, energy security and sustainable development.

This assessment report on the emerging environmental issues in Central Asia is timely and meaningful to the Central Asian region. The report, the first of its kind in Central Asia, identifies key emerging environmental issues in Central Asia – Atmospheric Brown Cloud, Dust Storms, Glacial Melt, Integrated Chemical Management and the Use of Alternative Energy Resources. These issues have been analyzed based on sound science by various experts, including scientists, academics and civil society representatives, to determine their impact on environment and population. Based on the analysis the report identifies the gaps in the existing system to address the emerging environmental issues and provide clear recommendations to fill the gaps.

I believe that this report will bring emerging environmental issues to the attention of different stakeholders including the general public. This report will also provide a sound basis for decision makers in Central Asian countries in addressing the emerging environmental issues at the policy level. I hope that this report will help for a collective response through policy intervention.

I would like to express my gratitude to the Governments of Central Asia and associated experts, especially the Interstate Sustainable Development Commission and its Scientific Information Centre (SIC) for producing this report through a fruitful collaboration.



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RENEWABLE ENERGY RESOURCES IN CENTRAL ASIA

Foreword

Recent researches suggest that there are a number of environmental challenges emerge that will threaten the nature and well-being of the Central Asia population unless proactive and immediate actions are undertaken. Central Asia possesses significant amount of mineral resources, abundantly endowed with conventional energy wealth and well developed industries. Rising economies of the states have been posing ever-growing threat to the fragile ecosystems, biodiversity, air and water resources in Central Asia.

This Report is the first of its nature undertaken in Central Asia. It identifies and suggests the ways of addressing sub-regional emerging environmental issues, such as: Atmospheric Brown Cloud, Glacier Lakes Outburst Floods, Renewable Energy and Integrated Chemical Management. These issues have been analyzed by various experts, including scientists, academics and civil society representatives, to determine their negative impact on environment and population

This Report was prepared following the decision of the Interstate Sustainable Development Commission of Central Asia and is based on the discussion of the sub-regional Ministers of Environment during the Ninth Special Session of the UNEP Governing Council/Global Ministerial Environment Forum that took in place on February 7 – 9, 2006 in Dubai, UAE.

The main objective of the Report is to identify, analyze, assess and provide scientific data and information for decision makers to timely address regionally significant emerging environmental problems.

The analysis, assessment and preparation of reports were carried out by SIC ICSD and Cooperation Centers in all countries and approved at the meeting of the Commission on 23 November 2006 in Ashgabat, Turkmenistan.

ATMOSPHERIC BROWN CLOUD

Assessment Report on an emerging issue ***"Atmospheric Brown Cloud"*** in Central Asia has been prepared pursuant to the decisions of the Interstate Committee on Sustainable Development (ICSD) and results of the Meeting of Ministers of Ecology of Central Asian countries at the 9th ad hoc Session of the Management Council of the Global Environmental Facility GEF with the UNEP support and on the initiative of Surendra Shrestha (Director of UNEP Regional Resource Center for Asia and the Pacific (UNEP RRC. AP, Bangkok, Thailand)) within the framework of project proposals on priorities of the Regional Environmental Action Plan (REAP) "Monitoring of Dust and Salt Transport and ABC in Central Asia" on emerging issues in Central Asia.

The goal of the Report is to get familiarized with the state of ABC research in Central Asia and justification of the need for monitoring of dust and salt transport and ABC; to provide with real scientific information for decision-making at the regional level; to prepare preliminary data for further purpose-oriented works on study and evaluation of eventual ABC impacts, dust and salt aerosols on sustainable development of the region and environment improvement.

Evaluation of environment condition in Central Asia and of dust and salt transport impact on the aerosol pollution of the atmosphere is made on the basis of results presented by a regional group of experts of Kyrgyzstan through analyzing the results of atmosphere probing at lidar station Teploklyuchenka.

This work is intended for decision-makers, scientists, representatives of the public, non-governmental organizations and citizens showing concern about the future of a human being and condition of the natural environment and sustainable development of Central Asia.

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INTRODUCTION

Involvement of Central Asian countries in studies of the problem "Atmospheric Brown Cloud" is of paramount and principal significance for the region. This problem has something in common with the problem of greenhouse gases that is being resolved within the framework of Sustainable Development Program and covers all traditional spheres, such as economics, biodiversity, healthcare, climate and ecology.

At present it is known that brown clouds are capable to reflect and absorb solar radiation and contribute to the cooling of atmosphere and the planet's surface. This may be one of the principal elements of the growing effect of global warming.

Brown clouds may initiate reduction of rains and atmospheric motions. For example, a dense part of aerosol pollution in the form of a giant Atmospheric Brown Cloud *(Fig. 1)* detected by the NASA satellite over Japan and the Pacific reached the United States of America in about a week.

One of the problems faced by the Central Asian region is a hazard of environmental crisis due to growing anthropogenic pressure on the natural environment, in particular, through the growing pollution of the air basin. The real example is the Aral disaster that has demonstrated to the whole world what the irrational natural resources management may lead to. The dust storms blow up from the dried sea bed millions of tons of hazardous solonchak dust that spreads to great distances and accumulates on the underlying surface of the Earth.

Atmospheric Brown Cloud is a major emerging environmental issue. Till recently it was mistakenly considered that such clouds are confined to boundaries of urban areas, for example, as the Denver Brown Cloud in the USA. Recent researches and satellite data show that brown clouds (or brown gas) cover vast territories, including whole continents and oceans. Thus, the results of the special experiment conducted in 1999 in the Indian Ocean (INDOEX) *[1]* have demonstrated that the Asian Brown Cloud covers the major part of the Arabian Sea, Bay of Bengal

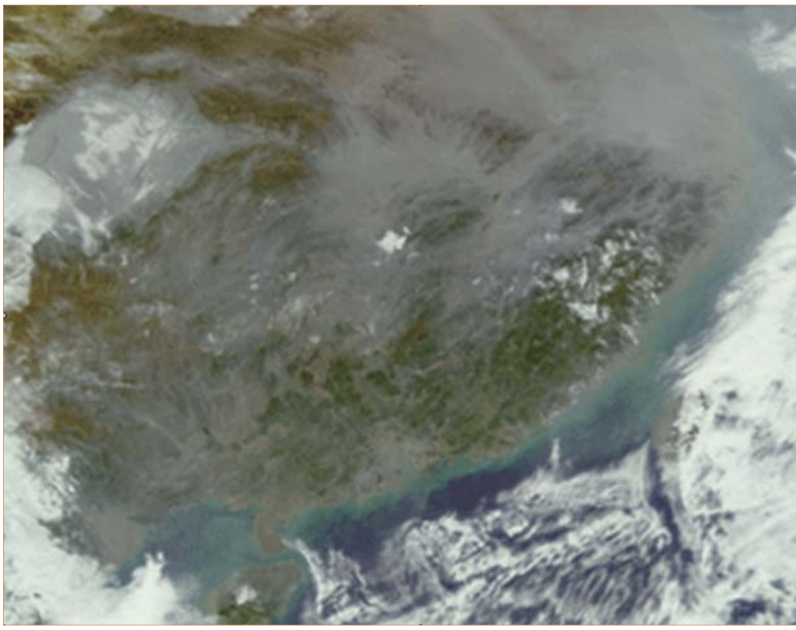

Fig. 1. Giant Atmospheric Brown Cloud over Central Eastern China (above) and enormous dust storm over China (below). NASA Satellite images.

and Southern Asia, i.e. the area approximately equal to the size of the USA territory *[2]*. The data from NASA satellite indicate that the atmospheric aerosol pollutions extend over vast regions of the world. UNEP has generalized these phenomena known as the North American Brown Cloud, Asian Brown Cloud and African Brown Cloud remaining ABC abbreviation and proposed to call it as ""Atmospheric Brown Cloud".

While the greenhouse gases act globally, the effects of aerosol pollution acts regionally. The scattering and absorption of solar radiation by aerosols exert cooling effect at the underlying surface of the Earth (decrease in temperature), while the absorption at the atmosphere by absorbing aerosols such as black carbon warms the atmosphere. Aerosols promote unsymmetrical changes in temperatures between atmospheric brown cloud and underlying surface of the Earth. While the global warming suggests the increase of precipitations the aerosol effect may lead to their reduction.

The Aral tragedy and existence of the Atmospheric Brown Clouds showed us that the aerosol environmental safety is among the basic strategic components of the national security and the most important aspect of the state priorities.

Detection and analysis of the Atmospheric Brown Clouds will make it possible to find out how these clouds are formed, how dust and pollution particles are driven to the regions of Central Asia and how they affect the natural environment, regional climatic changes, glaciers, hydrological and agricultural cycles, the life quality, health of the people and sustainable development of the region.

1. ATMOSPHERIC BROWN CLOUD

1.1. What is atmospheric brown cloud?

Still in the 80s of the previous century the US aviators from the Naval base "Diego Garcia" discovered a huge dirty cloud spreading from China in the east to the Arabian Sea in the west.

In the course of an integrated experiment in the tropical part of the Indian Ocean (INDOEX) (see Introduction) the scientists detected a dense brown layer of smoke pollution covering a great part of Southern, Southeastern Asia and a tropical part of the Indian Ocean *[1]*. Haze is a mix of various pollutants, mostly soot, sulfates, nitrates, organic substances, volatile ash and mineral dust *(Fig. 2)* that got into the atmosphere as a result of burning of fuel by vehicles, biomass in rural areas and emissions from industrial enterprises. Due to absorption and scattering of sunlight by such aerosols light haze of brown colour (smog) appears because of presence of soot (black carbon) there.

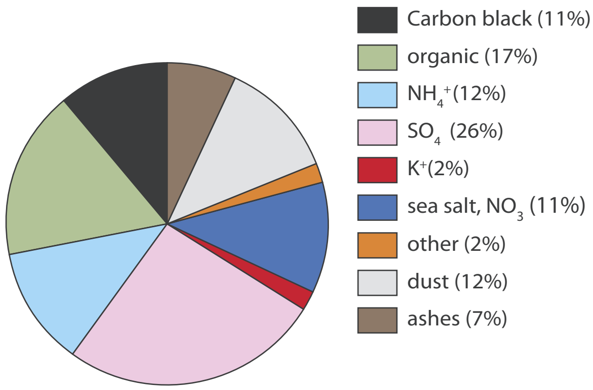

Fig 2. Relative contributions of various chemical components into aerosol optical depth *[3]*

1.2. Effects of atmospheric brown cloud

Clouds intercept a fraction of incoming solar radiation through scattering and absorption. The presence of black carbon in atmospheric brown clouds, however, can cause absorption of 25% or more solar radiation and facilitate warming of the atmosphere. Pollution decreases the ability of the cloud to generate precipitations, thus, extends the lifetime of brown clouds. As a result the amount of solar radiation that reaches the Earth's surface is reduced as well as the amount of precipitations in a region. Brown clouds move with the air masses flow, but the trajectory of their movement has not been studied well enough.

Depending on the fact, which of the circulations prevails in the lower layers of the atmosphere – cyclonic with upward flows or anticyclonic with downward flows – draughts or floods occur. Such natural disasters as acid rains, floods (for example, in Bangladesh, Nepal, Northeastern India), draughts in Pakistan, Northwestern India and South Africa may be associated with ABC. *[1-3]*.

The life of a lot of millions of people is in danger due to toxic smog and related changes in weather conditions. ABC provokes thousands of fatalities from diseases of respiratory apparatus and cardiovascular system annually.

In the recent years the project called "ABC-Asia" has been realized with the UNEP support. Within the framework of this project a network of stations is deployed at selected sites across Asia for land-based monitoring with a view to study the composition and seasonal distribution of smoke pollution.

Klaus Tepfer in May 2004 in London mentioned the results of studies of Asian smog and predicted what terrible consequences might occur due to ABC effect: "The brown cloud is a delayed-action bomb in arsenal of weapon destructive to the Earth's climate. It is unknown when indeed the bomb explodes. It is only known that consequences of this will be different in different parts of the world: longer periods of drought in Asia and showery rains will become more frequent in Northern hemisphere (in Europe)".

1.3. Where the atmospheric brown clouds may be located

The data from NASA satellite indicate that thick polluted layers of smog extend practically in all regions of the world. Thus, it is the North American Brown Cloud in American Continent, African Brown Cloud in Africa, Southern Asian Brown Cloud (Asian Brown Cloud) in Asia that is located over vast regions of South-Eastern Asia where nearly half of population of the Earth lives.

By means of an aerosol transport the brown clouds reach the Central Asian region. Apart from the distant transborder transport of aerosols, the local (regional) sources of atmosphere pollution make a significant contribution into the formation of ABC and Asian dust. Thus, according to the data of only one Lidar Teploklyuchenka Station *[4-9]* in Central Asia appearance of the occurrence of similar aerosol formations in Central Asia may be connected with active anthropogenic activity in Kazakhstan and transport of the great quantities of dust and salt from the Aral Sea basin. The ABC transboundary transport is usually observed from Southern Asian and the Near East region *(Fig. 3)*, while dust and salt transported from the Aral Sea basin.

1.4. Impacts of the atmospheric brown cloud on the natural environment and society

Brown clouds and natural events. The atmospheric brown clouds mixed with the dust during the dust storms (yellow sand events) and salt containing the great quantity of aerosols sharply deteriorate the visibility, cause variations in atmospheric composition, and also affect human health. Particles of black carbon mixed with dust and salt are carried with air masses and facilitate formation of atmospheric brown clouds in Central Asia region (International

Project "Aerosol Characterization Experiment – Asia"). The great quantity of soot is contained in the composition of such particles transported by a wind from Mongolia. The atmosphere pollution is added with the particles of salt and dust raised by wind from the dried out Aral Sea bed as well as great quantities of sand mixed with dust particles from the deserts of Central Asia *(Fig. 4)*.

Brown clouds and global warming. The brown clouds promote decrease in precipitations and localize cooling. Absorption of solar energy by a brown cloud reduced the amount of energy reaching the ground surface and warms the atmosphere. This leads to atmospheric stability and hence inhibits updrafts. Black carbon influences the thawing of glaciers and snow cover due to warming of the atmosphere. While the greenhouse effect is the main problem of the global climatic changes, the brown clouds are one of the main factors in regional climatic changes and reduction of the regional and global precipitations.

Climate. The problems like haze and acid deposition get into a general category of "Air pollution". Aerosols and high values of ozone concentration, due to impacts of polluting emissions into the atmosphere by enterprises of the agricultural-industrial complex, are a part of the global warming problem because they can stimulate climate changes and influence on the radiation balance of the planet. Their presence provides considerable effect on ecosystems, agriculture and human health.

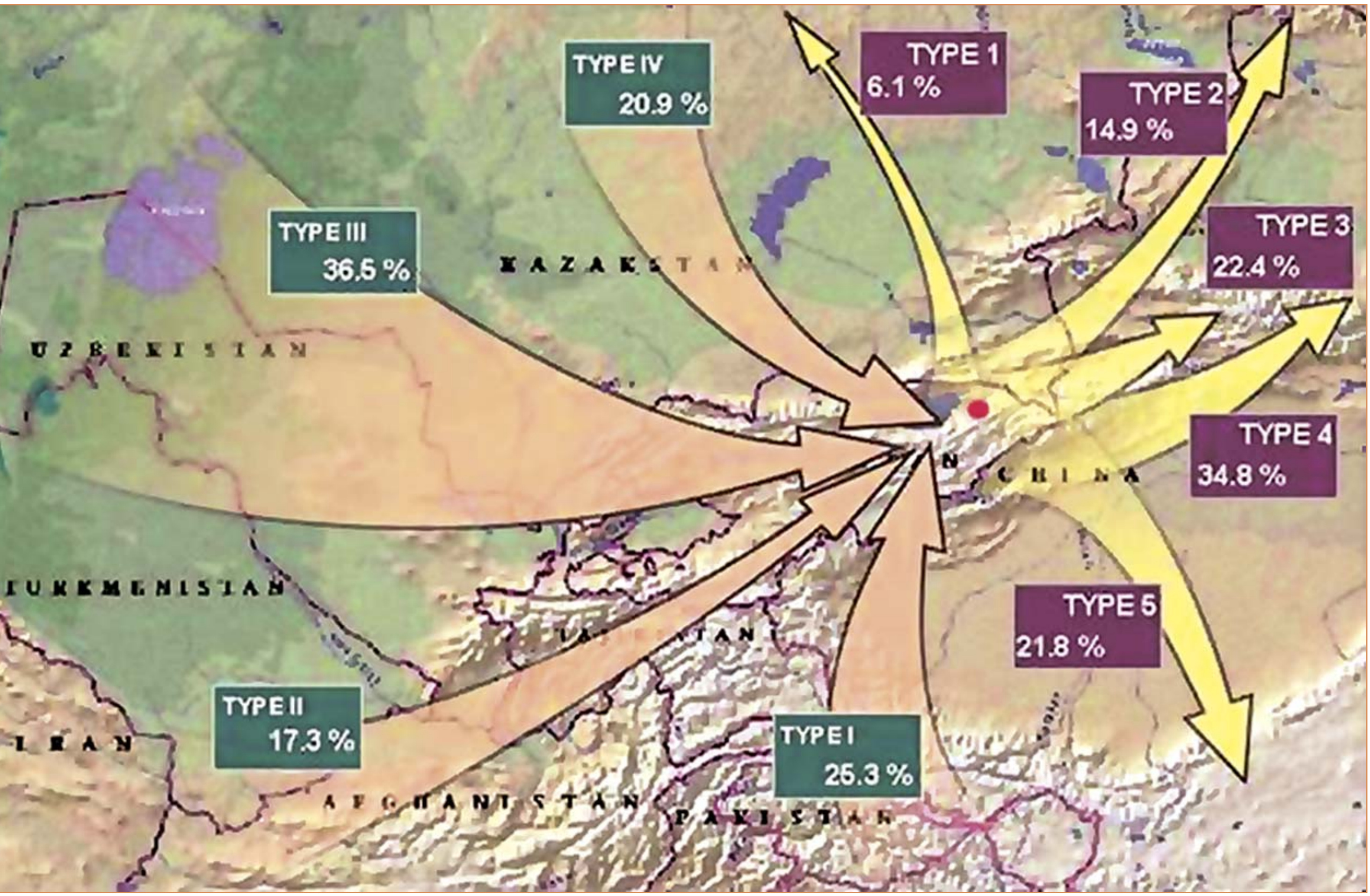

Fig 3. Recurrence of outflow and inflow paths of transport of atmospheric aerosol pollution to/from Central Asia (according to the Lidar Teploklyuchenka Station data, measurement processing at 3.500 m above sea-level)

Reduction of solar energy reaching the ground surface causes considerable consequences as a result of climate changes, such as:

- changes in temperature;
- changes in the precipitation regime;
- changes in agricultural seasons;
- glacier and snow cover thawing
- changes in radiation balance both in the atmosphere and the underlying surface.

Human health. Approximately 3 million people per year, 90% of whom live in developing countries, die because of the air pollution. Air pollution damnifies more than 1.1 billion people *[17]* and air pollution because of burning of wood, animal wastes and coal to heat premises, affects the health of about 2.5 billion people, more than 90% of whom live in developing countries. Standards set by the World Health Organization for suspenses particles and sulfurous dioxide are exceeded in Asian mega cities.

Agriculture and brown clouds. Atmosphere aerosols and gaseous pollutants provide direct unfavourable impact on yields of agricultural crops. Indirect impact of aerosols on agriculture is as follows.

- changes in hydrological cycle;
- changes in precipitation regime;
- changes in the yields of agricultural crops, in particular wheat, rice and others.

Wet deposition of acid, alkali and salt components reduces the yields of agricultural crops and, in particular cases, leads to the loss of vegetation, intensifies pollution of soil, surface and ground waters, accelerates corrosion processes resulting in destruction of buildings, constructions, less stability and efficiency of operation of technological complexes.

Fig. 4. Fires in Kazakhstan (21.09.2002) (above); dust storm over the Aral Sea (18.04.2003) (below). Satellite images.

2. DUST AND SALT TRANSPORT AND ATMOSPHERIC BROWN CLOUD IN CENTRAL ASIA

Taking into consideration the specific climatic conditions and strenuous environmental situation in Central Asia due to drying out of the Aral Sea and intensive desertification processes, the assessment of the effect of atmosphere pollution becomes most important and urgent. This in particular concerns dust, salt and their transport from various pollution sources in correlation with the impacts of atmospheric brown clouds.

2.1. Specific features of the dust and salt transport and atmospheric brown cloud

The main sources of the dust and salt transport are the dust storms. In Central Asia this is most often observed in desert regions. Natural sources of dust are the Karakum and Kyzylkum Deserts as well as the dried out bed of the Aral Sea (Aralkum) *[10-14]*. The average annual period of dust storms, for instance, in Turkmenistan *(Fig.5)*, varies from 350 hours in the west to 15 hours in the south-west *[10]*. Dust storms could be observed during approximately the same period (up to 20 days a year) in Uzbekistan *[11-12]* and Kazakhstan *[13-14]*. In mountain regions of Tajikistan [19, 20] and Kyrgyzstan the period of dust storms is shorter and makes on the average from 1 to 10 hours per year.

The northern and southern coasts of the Aral Sea are one of the main sources of dust storms in Central Asia. In the recent decade the total number of dust storms in the region was registered at a level of 90-100 cases per year *(see Fig. 5)*.

Dropping of the water level in the Aral Sea led to formation of spacious sources of dust storms that blow off into the atmosphere the great quantities of aerosols of mineral origin *(Fig. 6)*. Salinity of atmospheric precipitations decreases with moving away from the territory of the Aral Sea. Increase in salt particles in the air will reduce the amount of solar energy reaching the ground, and also change the microphysical properties of the air mass. In dusty atmosphere the boundary layer gets heated that results in an inverse distribution of the temperature preventing the development of convection processes.

The level of air pollution in industrial centers is characterized by the increased concentrations of solid particles, often exceeding WHO standards. Solid particles less than 10 micron in diameter are hazardous disease-causing agents. It was found that high concentrations of such particulate matter cause diseases of the upper respiratory tract, chronic bronchitis and aggravate lung and cardiovascular diseases, thus, shortening the life span. The main source of such particles is burning of fuel in power generation and transportation. Steadily growing air pollution with great quantities of dust (approximately 200-400 mkg/m^3) that has been observed in the recent years in Central Asia is indicative of the fact that a greater fraction of solid particles gets into the atmosphere due to the man-caused desertification process.

Highly saline precipitations fall in the desert zone of the Aral Sea area *(see Fig. 6)*. This is indicative of a high level of air pollution with aerosols of mineral salts and their effect on radiation characteristics of the atmosphere. High levels of anions-hydrocar-bonates, sulfates, chlorides, and among cations – calcium and magnesium, were found in the rain water. In industrial regions the level of sulfates, nitrates in atmospheric aerosols is increasing. In the Aral Sea region the quality of water and land resources is deteriorated, the composition and stability of ecosystems are disturbed, the environment toxicity has increased. Every year 75 million tons of sand and dust and approximately 39 million tons of salts are raised into the atmosphere with sand storms. The new desert Aralkum has already swallowed up two million hectares of arable lands, caused degradation of pastures, tugai forests and other vegetation.

Air flows carrying dust and salt from the Aral reach as far as 800-1000 kilometers into densely populated oases and settle down on glaciers where main rivers of Central Asia take their origin *[18]*. By now 1081 glaciers disappeared in the Pamir-Altai, 71 glaciers in the Zailyisky Alatau, the glaciers in the Akshyirak area has shrunk. During a year the valley glaciers in Tien-Shan and Pamir are recessed by 3-13 m on the average. This process is accompanied by their flattening. Thus, for example, according to estimates of glaciologists from Tajikistan, if the present rates of glacier degradation are maintained, by 2050 the glaciation area will have become 15-20% less, while the volume of ice will have reduced by 80-100 cu. km. For Central Asia this is a dangerous process, because mountain glaciers are the only century-old storehouses of fresh water reserves and the principal area of condensation of atmospheric moisture in the region.

Research results show that every year deserts in the southeastern part of Mongolia and in Eastern Kazakhstan become sources of winter and spring sand storms threatening China. Images made from satellites on 18.05.1998 and 18.09.1998 provide a pictorial view of formation and results of numerical restoration of a trail of sand and salt blowout from the dried out Aral Sea bed *(Fig. 7)*.

ABC over the lidar station Teploklyuchenka is observed in the lower and upper parts of the troposphere. If in Southern and Southeastern Asia ABC is formed and developing due to anthropogenic aerosols as a result of burning of biomass and fossil fuel *[1-3]*, the appearance of ABC in the lower troposphere in Central Asia is connected with the presence in the region of local pollution sources and ABC in the upper troposphere-with its long-distance transboundary transport *(see Fig. 3)*. When air masses moved by dust storms get into piedmont and mountain regions the dust storm

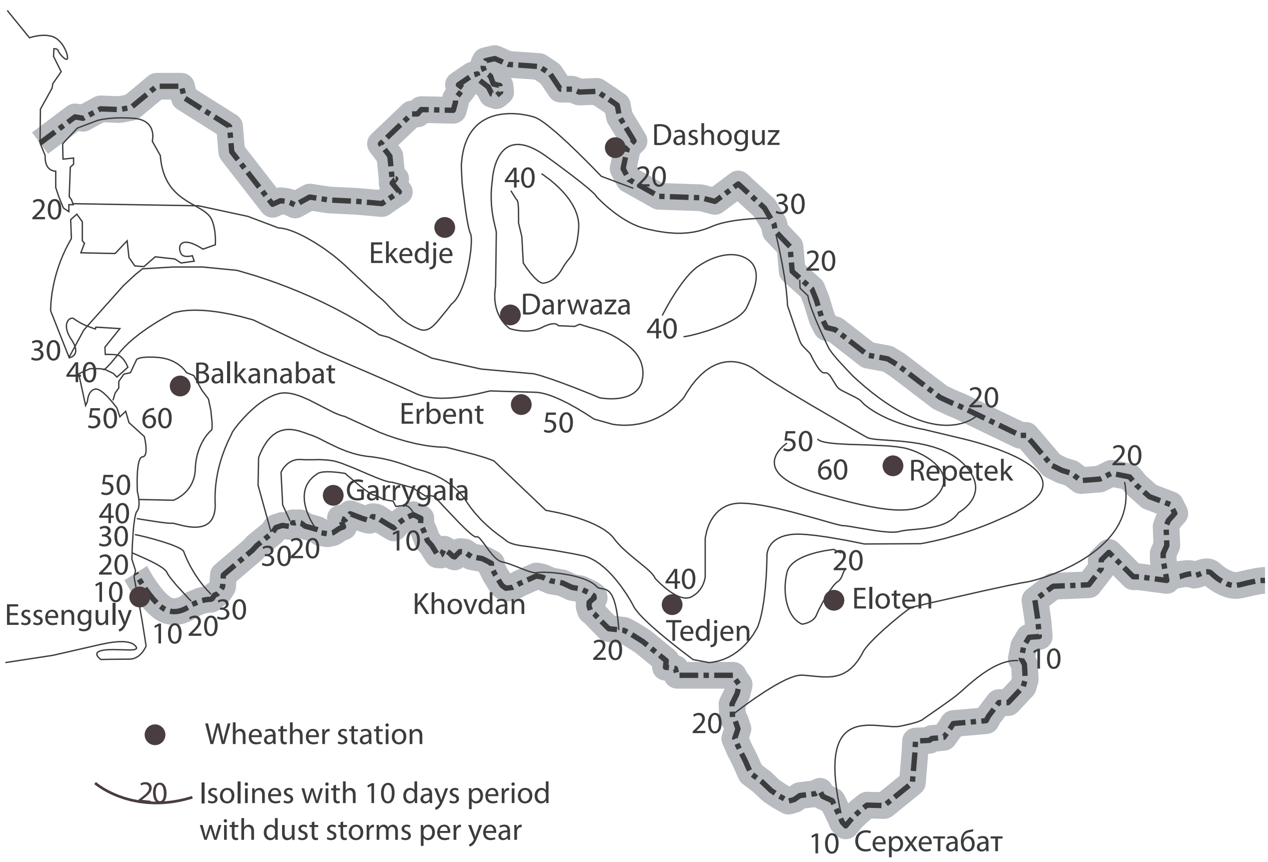

Fig. 5. Map of dust storms distribution on the territory of Turkmenistan (average annual number of days) *[10]*

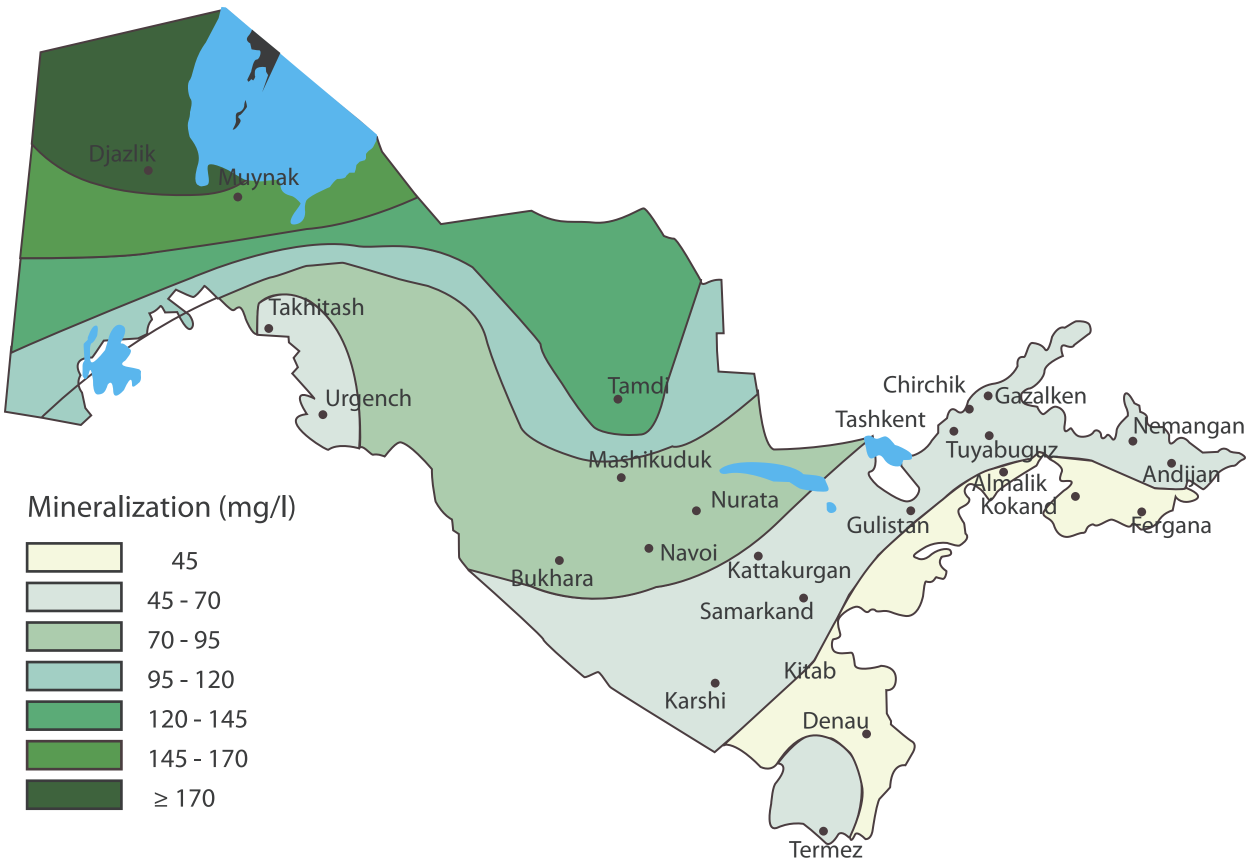

Fig. 6. Salinity of atmospheric precipitations (average long-term data) on the territory of Uzbekistan

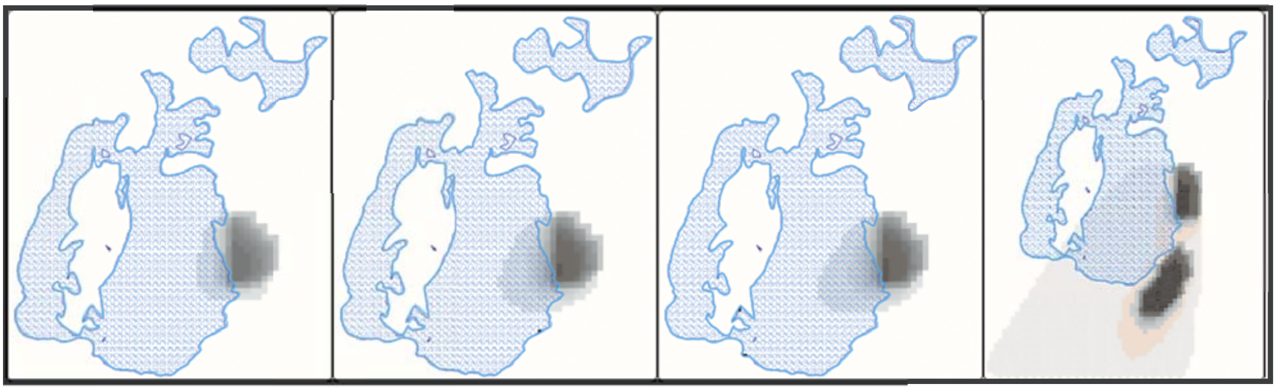

Fig 7. Sand and salt blowout from the dried out Aral Sea bed (18.05.1998, 18.09.1998)

Fig. 8. Direction of dust storms and haze migration (Hydrometeorological Agency, Tajikistan)

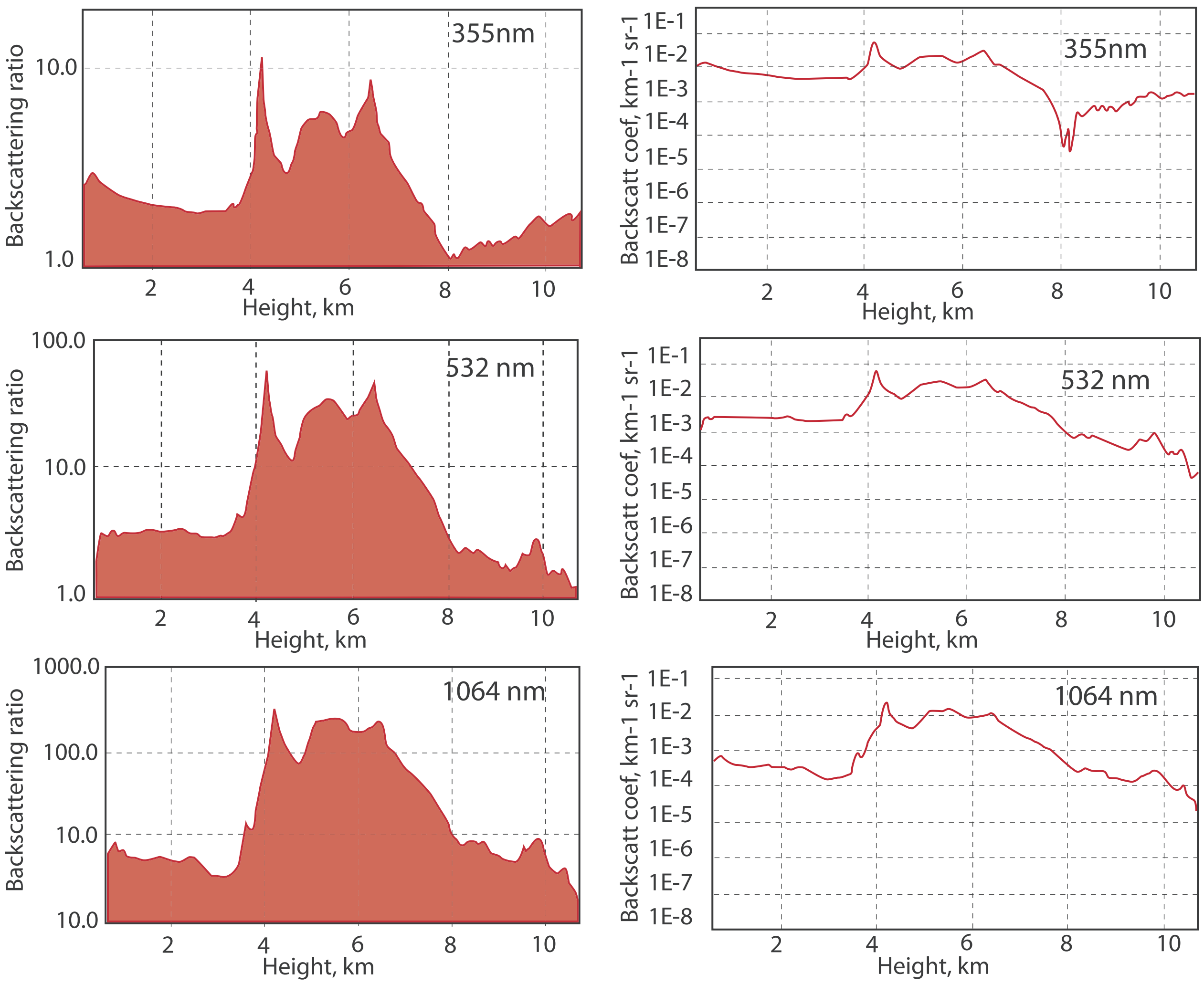

Fig. 9. Vertical profiles of a ratio of dissemination and back scatter coefficient for three probing wavebands. 04.04.2002 (Lidar Station Teploklyuchenka) [8].

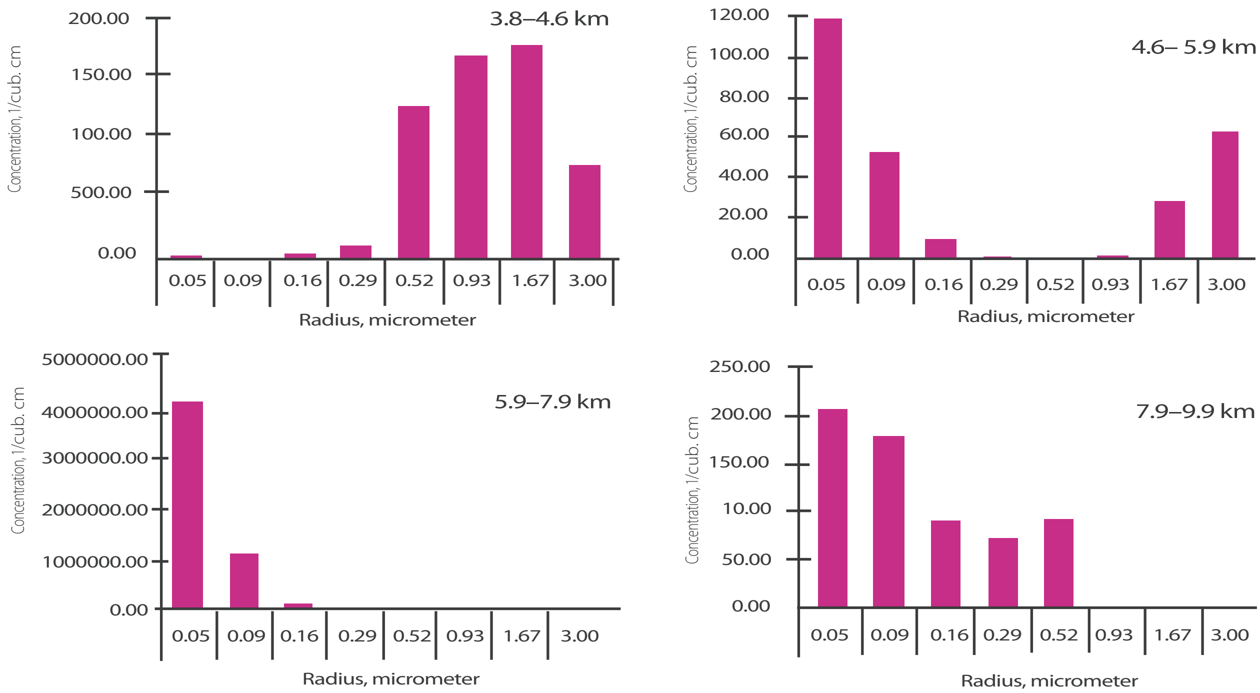

Fig. 10. Distribution of concentration of particles by sizes in various layers of dust and cloud *[5]*.

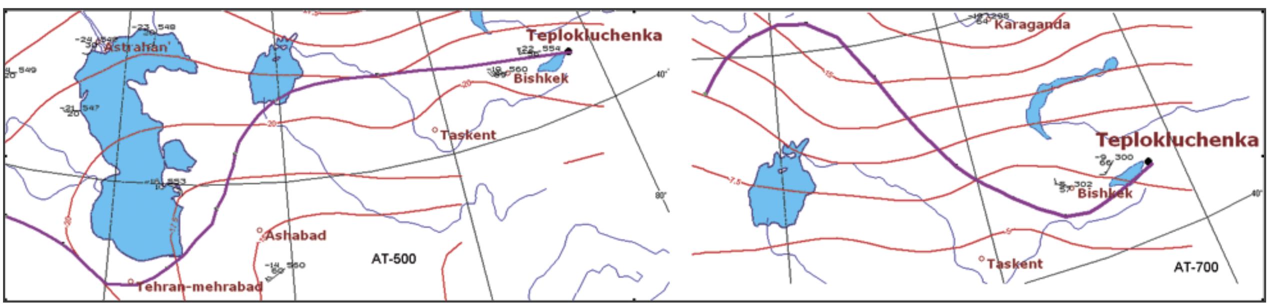

Fig. 11. Back trajectories of 4D particles on AT-700 (left) and AT-500 gPa (right) 04.04.2002 *[4-8]*.

gradually turns into an advective haze [11, 12]. In their great majority the Central Asian dust storms are surface events (approximately 10 or 1000 m by a vertical) that certifies against the great dustiness of high-mountain areas [15, 16]. However, there are observed potent vertical dust storms that get into mountains and affect glaciers. In Tajikistan more often than dust storms there is observed a formation of a dense gray haze (locally called “Afghanets”) at a height of 1-3 km that covers the sky and mountain tops with compact gray layer *(Fig. 8)*.Twice in the past century (in the 50s and 80s) an orange haze that made the sky and glaciers of orange color affected Tajikistan from the east (Takla-Makan Desert in China).

Due to orographic intensification of wind and local circulation the brown (gray, orange) haze may migrate from one valley to the other from the opposite side of a watershed ridge. Such mechanism may take place during the brown cloud transfer (haze, mist), for instance, from Kazakhstan over Zailyisky Alatau to high-mountain areas of Tien-Shan or during movement of the South-Asian Brown Cloud over the Pamir to Central Asian regions from Western China and Tibet *(see Fig. 3)*.

It was found with the lidar probing of the brown clouds *(Fig. 9)* that dust was always present in the lower troposphere. *[8,9]*. A vertical profile shows that at the bottom where dust is mostly available the larger-size particles concentrate, while in the top layers – smaller ones *(Fig. 10)*. A back trajectory analysis of a map of 700 gPa isobaric topography has shown that dust particles get to the region from Caspian steppes, from the Aral Sea area and Northwestern Kazakhstan, while ABC – from Iran and Saudi Arabia *(Fig. 11)*.

Consequently, long waves not only move and develop, but increase the wind amplitude and velocity in the system of these waves. Formation and movement of a frontal cyclone under the frontal part of an upper trough cause blowout of warm air from the south to higher latitudes. This process is being intensified due to a temperature rise under the cloud because of trapping of long-wave radiation by the cloud and its high capacity to absorb solar radiation. Under the rare part of the upper trough the cold is transferred from north to south due to anticyclone formation and migration.

Wave amplitude Rossbi increases due to the amplification of a wave crest in front of a trough and deepening of a trough because of meridional heat exchange. Further on with the amplitude growth a closed cyclonic circulation is formed in an upper trough and, as a result, the focus of cold is isolated in the south, while in the upper crest the closed anticyclonic circulation is formed and an isolated focus of warm appears in the north. As a result, the wave gets destroyed and later on the described cycle may repeat *[4-7]*.

In view of the enormous size of the brown cloud some its part may locate on the cyclonic side, while the other part – on the anticyclonic side of a wave. The part within the cyclonic side may experience heavy precipitation while a dry weather and droughts may be observed in the region within the anticyclonic side.

2.2. Sources of the dust and salt transport and atmospheric brown cloud

The observed steady tendency of decreasing the direct solar radiation over the Earth's surface is connected with large-scale processes in the atmosphere, in particular, with the general intensification of aerosol pollution or intrusion of air masses with other optical properties into Central Asia. In case of solar radiation decrease due to regional factors a good coordination among all actinometric observation stations should be ensured. In fact, in winter when the anticyclone weather regime dominates, the scientists from Kazakhstan have found, paired correlation factors of radiation measured by different stations proved to be very high, especially for one-type physiographic regions (0.74-0.76). Correlation coefficients between remote stations abate up to 0.39-0.40. In a warm season of a year a good correlation is seldom observed and only for separate stations. This indicates that against a general background of decreasing transparency a greater role is played by local sources of atmosphere pollution. In particular, this may be dust from desert and southern regions of Central Asia.

The analysis of back trajectories of air masses helps to trace and analyze the aerosol transport with air masses to considerable distances. HYSPLIT (Hybrid Single-Particle Integrated Trajectory) Model is a hybrid model of an integrated trajectory of a single particle *[http://www.ari.noaa.gov/ready/hysplit4.html]* was used to analyze the trajectories, with the meteorological data from meteorological archive FNL NOAA USA. Two basic features of their typification were identified:

1) by types of air masses;
2) by sources of aerosol pollution.

Trajectories of each of the types differ essentially by migration territory and movement rate of air mass. It should be noted that a greater part of aerosol pollution during four-day (4D) migration either settles down due to gravitational forces or falls out with precipitations. The sources of aerosol generation located at a distance up to 5,000 km make the greatest contribution to ABC [4, 11].

Classification of back trajectories by types of air masses: warm, cold and converting.

Back trajectories of warm air masses locate completely to the south of the planetary high-altitude frontal zone, cold air masses – to the north of the planetary high-altitude frontal zone. The transforming trajectories locate along the planetary high-altitude frontal zone.

Fig. 3 shows the major paths of air flows to the region in question. Trajectories of cold air masses are repeated more seldom than of warm ones and make 42% of all cases. Pollution by aerosols of natural origin is low; at the same time the contribution of anthropogenic aerosols is increased: motor transport, industrial centers, etc.

Classification of back trajectories by pollution sources. Back trajectories of air masses passing over certain region are indicative of the presence of major sources of aerosol pollution that may be divided into two categories: natural and anthropogenic.

The anthropogenic sources include all major industrial centers, conglomerates, coal and other raw material mining and processing. However, the greatest contribution to aerosol pollution of the troposphere over the Central Asian region is made by natural sources – vast deserts, semideserts, steppes lying on the way of air masses migration.

Natural sources of pollution of air masses coming to the region include the following areas *(see Fig. 3)*:

Type I. Southern Asia and China (Takla-Makan desert);

Type II. Northern Africa (Sahara, Libyan Desert), the Near East (Arabian deserts, Iranian Plateau, Afghanistan);

Type III. Povolzhie, Western Kazakhstan (steppes, semideserts, deserts, Caspian Lowland, Ustyurt Plateau, Aral area, Karakum, Aralkum, Kyzylkum Deserts);

Type IV. Northeastern Kazakhstan (Kazakh bald hills, Betpak-Dala, Moiynkum, Taukum Deserts).

The most long-distance transfer of aerosol pollution to the region is done by trajectories of types II and III, when during four days a distance of several thousand kilometers is covered from the north of Sahara in the Near East or the Atlantic and Western Europe. But such trajectories were observed only in 7.27% and 3.64% of cases, respectively. Most frequently the aerosols are carried with air masses from the Caspian Lowland and from the Aral Sea basin (type II).

In conditions of Central Asia the problem of studies of impacts of brown clouds on the natural environment is aggravated by some specific features, including climate, intensive anthropogenic activity (developed agro-industrial complex) and environmental crisis in the Aral Sea basin. All these factors in conditions of arid climate induce formation of dust storms and surface sand drifts, dust and salt storms. Intensified are processes of photochemical smog formation being a precursor of secondary fine aerosols making up brown clouds. Transboundary transport of man-caused and natural aerosols (dust, salt) over the territory of the region gives rise to complicated physico-chemical processes in the atmosphere related to the formation of secondary aerosols making up brown clouds and affecting the climate system in the region and natural environment.

2.3. Measurements of optical and microphysical characteristics of the dust, salt and atmospheric brown cloud by lidar method

The studies of optical and microphysical properties of aerosols and brown cloud have been conducted at Lidar Station Teploklyuchenka *[4-9].*

Optical characteristics of dust and ABC

1. Dust has a varying thickness from 0.5 to 3.0 km and locates at a height of up to 5.0 km over the station. Optical depth of dust aerosol at H_a=532 nm reach τa =0.58, and damping coefficient 0.7 km^{-1} at a height of 1.4 km *(Fig. 12).*

The main sources of dust in the region are sandy deserts and arid territories with loess-like soils (the Near East, Central Asia, China, Northwestern Kazakhstan (Caspian), Aral and others). The most dense aerosol layers *(Fig. 13)* are found on the northwestern border between Turkmenistan and Uzbekistan that may be connected with salt and dust sources in the dried out Aral Sea bed, a complex of sandy and solonchak (alkali soil) deserts in the north-west of the Karakum and south-west of the Ustyurt-Mangyshlak plateau.

2. Aerosol formations like Atmospheric Brown Cloud practically are always located at a height close to the upper limit of a layer of active turbulent mixing (2.0-4.8 km). At vertical height from 600 to 1500 m the average optical depth equals Ha =0.34±0.26 (l=532 nm), which is typical of such aerosol formations, for example, South-Asian ABC. More often ABCs are mixed by phase. A ratio of reverse dispersion, R, reaches 50 and more at l=532 nm and up to R=200 at 1=1064 nm *(Fig. 12).* A depolarization ratioin ABC mounts to the value of 0.2-0.25, while in dust aerosol due to the presence of non-spherical particles – 0.25-0.45 usually at moderate values of R.

Microphysical characteristics of dust

I. The shift of a distribution function to the area of small-disperse and submicron sizes of particles has been observed.

2. Concentration of a Submicron (fine) fraction (r = 0.10-1.0 micron) in dust in comparison with the background aerosol is approximately 100-fold higher, while of a ultrafine fraction with radii r=0.05-0.10 micron – more than 500 times as much and sometimes considerably exceed the concentrations (up to 500 micron/cm^3 and more) in Sahara dust in the Mediterranean region.

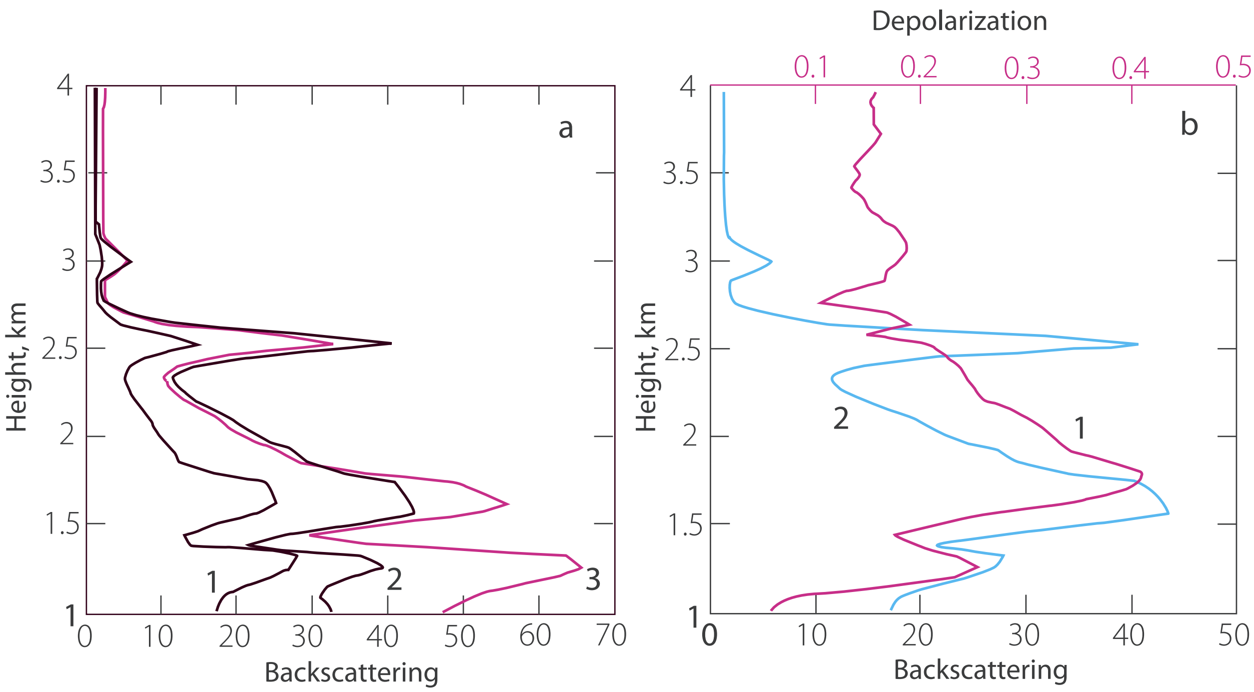

Fig. 12. Vertical profiles of dispersion ratio R(h) (a) for three wavelengths: 1) 1=355 nm, 2) 1= 532 nm, 3) 1=1064 nm and superimposed depolarization curves D (1) and dispersion ratio (2) for wavelength 532 nm. Dust. 03:56 hr. 08.08.03 *[8].*

3. Positive tendency is observed in the values of microphysical parameters with the study results of intensive dust storms in the Aral Sea region *[11]*. The difference is in the lower (2.0-2.5 times) content of small particles (r=0.05-0.5 micron) and shifting to the area of smaller radii of particles in a monodisperse range of sizes.

Microphysical characteristics of ABC

1. Concentration of particles on the lower border of ABC is much higher than the background one. Thus, a concentration of particle fraction r=0.05-0.16 micron exceeds the background one up to 7-10 times; r=0.29-0.52 micron (particles of coagulation consolidation) – from 20 to 200 times; r=0.93–3.00 micron – up to 8-fold.

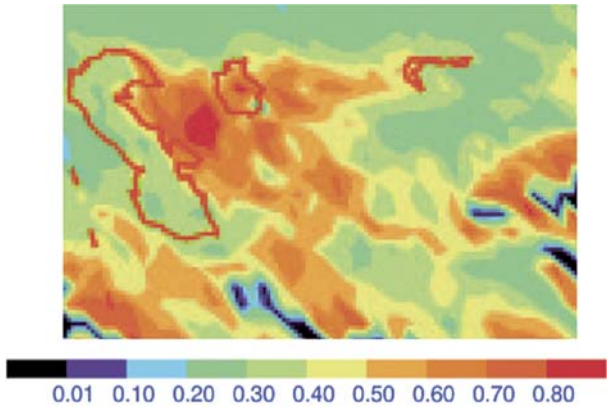

Fig. 13. Average optical depth of atmospheric aerosols for wavelength 550 nm during April-May 2001 and 2002 (NASA satellite *[2]*).

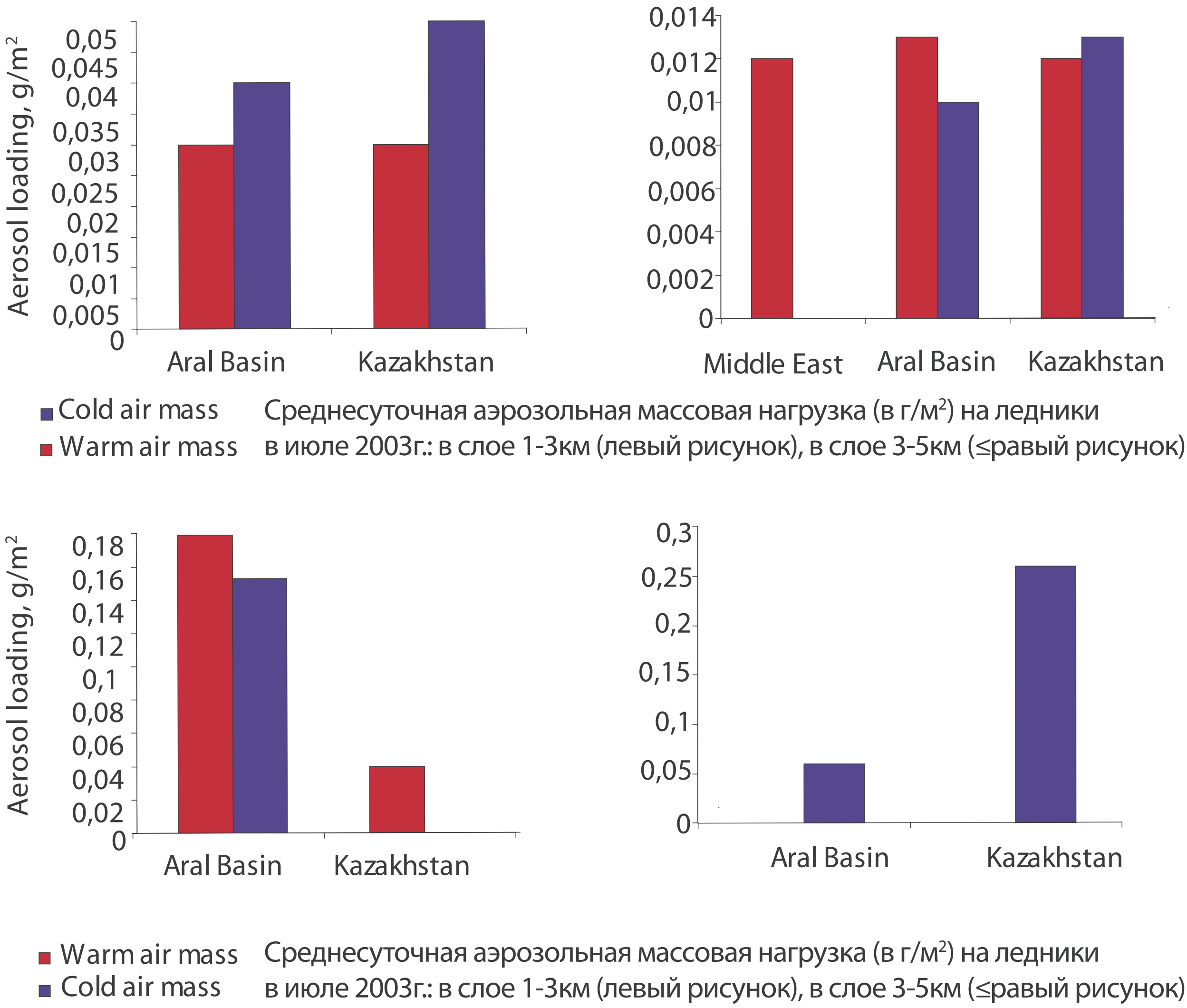

Fig. 14. Evaluations of average daily aerosol mass pressure on glaciers of Central Tien-Shan *[9]*.

2. The maximum concentration of particles r=0.93 micron in ABC is shifted to its lower border, a fraction of small particles (r=0.09-0.16 micron) has the maximum concentrations, while a fraction of submicron particles (r=0.29-0.52 micron) is characterized by concentrations, which values are approximately 2-fold smaller than the fraction of small particles. The maximum concentration of particles of a submicron fraction is concentrated in the middle or lower layer of ABC.

3. A submicron fraction plays the central role in formation of a back scatter coefficient at all wavelength in ABC. at the same time considerable changes in the imaginary part of a refraction index (k=0.005-0.08) in the area of height from the upper border of an active turbulent mixing layer to its lower border are connected, as a rule, with the soot component of aerosol.

4. The effect of a soot component on absorbing properties of aerosol in the absence of clouds is restricted usually by heights of 1.5 km for background aerosol and 2.5-3.5 km depending on a condition of the active turbulent mixing layer.

5. Great masses of aerosol falls out on glaciers of the Central Tien-Shan during dust and salt blowout from the Aral Sea basin (0.12-0.16 g/m^2 a day) and brown clouds from Kazakhstan (up to 0.22 g/m^2 a day) *(Fig. 14) [9]*.

3. PROGRAM OF MONITORING OF THE DUST AND SALT TRANSPORT AND ATMOSPHERIC BROWN CLOUD IN CENTRAL ASIA

A strenuous environmental situation arisen in Central Asia as a result of intensive economic activities has led to the increase of sources of aerosol emission to the atmosphere and increase of its general pollution. Fine mode particles of aerosols in the form of salt and dust spread to great distances polluting not only nearby territories, but also regions located at a distance of many thousands kilometers *(see Fig. 3, 6,11)*. If to all these the presence of a brown cloud over separate regions of Central Asia could be added, then we would be able to assert that the natural cycle of aerosols in the atmosphere of the region is violated.

Blowouts of great concentrations of dust and salt from the Aral Sea basin and other sources as well as availability of ABC explain a sharp pollution growth of glaciers in Central Asia *(Fig. 14)* and may lead to their more active thawing. This will facilitate formation and increase of the number of landslides that, in their turn, result in hazardous situations, especially in the regions of tailing dumps of uranium ore wastes storage, for example, Maili-Suu region in Kyrgyzstan. Such phenomena may induce environmental disaster that may cover a vast territory and a great number of the population than that happened in the Aral area, and will demand considerable efforts and funds not only from the Central-Asian countries, but from the whole world community.

In order to reveal the changes in natural cycles of atmospheric phenomena affected by anthropogenic activities and to assess the effect of dust, salt and brown cloud on the hydrological cycle (water balance), regional climate and economics, agriculture and human health, there is an urgent need to create a single unified system for monitoring the aerosol pollution in Central Asia.

3.1. Monitoring program

On the first stage during 3 years it is contemplated to create a regional system for monitoring of the Atmospheric Brown Cloud and a dust and salt transport in Central Asia (ABC CA-Net).

The following tasks are formulated for its realization:

Task 1. Finding places for the regional net of ABC observatories in Central Asia (preparatory period), coordination with the governments and formation of a regional network of ABC observatories comprising at least 6 observatories: 1 basic observatory in Kyrgyzstan on the basis of the Lidar Station Teploklyuchenka; 2 observatories in Kazakhstan and 1 observatory in Tajikistan, Uzbekistan and Turkmenistan each.

Task 2. Organization of ABC observatories and their equipment with identical facilities:

- receiving of official status for observatories; elaboration of a respective scientific
- methodological base;
- training of observation operators in the base observatory.

Addressing this problem will help organization and technical equipping of observatories with unified facilities with the parameters complying with the level of regional observatories formed within the framework of the UNEP Project ABC-Asia.

Task 3. Elaboration of a unified methodology for measurements and data processing, monitoring of ABC and dust and salt transport:

- elaboration of methodologies and programs for interpretation of observation results and mutual comparison and calibration of tools on the base and other observatories;
- land-based measurements on the base and other observatories during the selected period for measurement of large-scale distribution of characteristics of the air mass, radiation balance and chemistry of aerosol;
- modeling of dust and salt transport and a brown cloud to assess their impact on the regional climate, atmosphere chemistry, hydrological cycle, agriculture and human health.

A scientific network of observatories in Central Asian countries will allow to conduct regular coordinated researches and to receive objective data about spatial-temporal variations of characteristics of ABC, dust and salt as a result of large-scale transport.

Studies of ABC, dust and salt aerosol will be carried out on the basis of multipurpose measurements, including polarization and spectral lidar, radiation, chemical and also meteorological observations.

Based on analysis of measurement results from all observatories the quantitative characteristics will be obtained on variability of an altitudinal distribution of aerosol pollution from various sources, both of the regional scale and in the course of their transboundary transfer for assessment of climate changes in Central Asia and addressing environmental issues.

3.2. Measurable parameters

Economic development of the Central Asian region is accompanied by the growing emissions of aerosols and their precursor materials. Aerosols in Central Asia have a complicated structure, for example, aerosols of mineral dust mixed with polluted air include carbides and sulfate compounds. Radioactive properties of such aerosols are very complicated and not well studied. That is why it is very important to investigate the radiation characteristics of aerosols, their space and time variations related to the processes of emission, transfer, interaction and sedimentation.

Optical properties of aerosol to be studied:

- aerosol optical depth;

- distribution by sizes;
- absorption coefficients;
- single scattering albedo; Angstrom index.

It is known that the global average annual radiation impact of aerosol in the top of the atmosphere (TOA) varies in the range of 0 to-2 W/m^2. This is comparable but counteracting to, say, with the impact due to the increased concentration of greenhouse gases during the last century.

The existing considerable changeability of aerosol optical properties is determined not only by its types but by difference in sources of origin.

3.3. Modelling

There is a considerable variability of optical properties models under development lidar signals of reverse dispersion and a method of wavelet-conversions. A possibility to apply the model ACCESS (ABC Chemical Modeling and Emission Support System) will be studied that may enable modeling of a chemical transfer/transport and also of the Frontier Research Center model that makes it possible to conduct 7-day prediction of distribution of chemical components and sulfate aerosols.

Parameters measured and estimated by a network of observatories (optical properties of aerosol, surface mass concentration of BC, OC, sulfates, soil and salt dust, direct radiation impact on the at the top of the atmosphere (TOA), in the atmosphere, and ant the surface, effective radius of a drop of a cloud on its upper part above 273K) will be applied in modeling. The results may be presented as a 2-Dmap between 52.8 and 87.5E and 36.5 and 5.5N (Central Asia) as average daily values and time sequences of 6-hour average values per LSI.

The Eastern Asian model of the air quality EAAQM (East Asian Air Quality Model) or an improved 3-D Eulerian representation of chemical dispersion will be considered that may be used for analysis and interpretation of data on salt and dust transport.

3.4. Assessment of Impacts

Aerosol radiation impact. Central Asia is considered to be one of the regions, where a great diversity of aerosols is observed, including aerosols of fossil fuel, dust and salt. That is why there is a need to study the Aerosol Radiation Impact with regard to its spatial and temporal variations.

Assessments of direct and indirect aerosol effects in the tropical part of the Indian Ocean are presented for the pre-industrial period *[21]*. The underlying surface is affected much greater by aerosols than greenhouse gases. Here both direct and indirect impacts cause temperature lowering.

As a result of burning fossil fuel and biomass still greater amounts of SO_2, organic substances and soot aerosol are emitted into the atmosphere. The expanding transport sector increases the level of nitrogen oxides to the values similar to those observed in Europe and North America. In addition, dust and salt particles may lead both to cooling due to scattering of solar radiation in space and also to heating – as a result of absorption of infrared radiation making an aerosol situation in Central Asia more complicated.

Recent LST investigations have shown that in most cases the dust and salt are transported from the Aral Sea to Northern China and may develop into darker brown dust at further movement eastwards due to mixing with soot particles. Because of a higher content of black carbon the dust may absorb more solar radiation that afterwards may impact the local circulation in the atmosphere and result in regional climatic changes.

CONCLUSION

It was found that brown clouds periodically appear over Central Asia that are formed as a result of long-distance transboundary aerosol transfer from the regions of Southern Asia, Northern Africa and the Middle East, and impacts of local (regional) pollution sources in Central Asia. ABC affects the regional climate of Central Asia by reducing solar radiation and precipitations, localizing cooling and influencing the glaciers thawing regime, affects agriculture and human health.

For identification of disturbances in natural cycles of atmospheric events under the impact of the ABC, dust and salt transport on Central Asian ecosystems, it is necessary to create a common regional network of observatories for unified monitoring of aerosol pollution. At present aerosol environmental security becomes a strategic component of the regional security and the key aspect in state priorities for the Central Asian countries.

The project is targeted to provide a scientific basis for advised decision-making at the regional level, to study and improve the environment condition by assessment of likely impacts of ABC, dust and salt aerosols on climate changes, population health, thawing of glaciers, hydrological regime of water resources, agriculture (provision of the population with food) and sustainable development of Central Asia.

REFERENCES

1. The Asian Brown Cloud: Climate and Other Environmental Impacts. UNEP. 2002, 54 p.

2. Ramanathan V. and Ramana M.V. Atmospheric Brown Clouds. Long-Range Transport and Climate Impact. EM, December 2003. 28-33 P-

3. Ramanathan V. et al., Indian Ocean Experiment: An integrated analysis of the climate forcing and effects of the great Indo-Asian haze, 2001.

4. Chen B. B., Lelevkin V. M. Stratospheric aerosol layer over Central Asia. – KRSU Publishers, Bishkek. 2000. 228 p.

5. Lelevkin V. M., Chen B. B. To dynamics of the Asian brown cloud.//KRSU Newsletters. Series Physics. Issue 5. 2003. P. 116-122.

6. Lelevkin V. M., Chen B. B., Sverdlik L. G. Military actions in Iraq and atmosphere pollution. // KRSU Newsletters. Vol. 3. No. 2. 2003. P. 69-73.

7. Chen B. B., Lelevkin V. M. Influence of Atmospheric Aerosol Contamination on the Regional Climate in Central Asia. Proc. of the NATO ARW, Zakopane, 1-4 Okt. 2004. – Springer. 2006. P. 403-414.

8. Chen B. B., Sverdlik E. G., Kozlov P. V. Optics and microphysics of atmospheric aerosol – KRSU Publishers, Bishkek. 2000. 223 p.

9. Chen B. B., Sverdlik L. G. Optical Properties of Aerosols in Central Tien-Shan by the Laser Probing Data. – KRSU Publishers, Bishkek. 2000. 274 p.

10. Durdyev A. M., Orlovsky N. S., Orlovskaya L. G. On Dust Storms in Turkmenistan. Desert Development Problems, No. 4. 2002.45-54 p.

11. Romanov N.N. Dust Storms in Central Asia //Proc. of TashGU, Issue 174. Physical Sciences. Book 20. Tashkent. 1960.109-111 p.

12. Tolkacheva G. A. Scientific-Methodological Monitoring of Atmospheric Fallouts in the Central Asian Region. Monograph.-Tashkent: SANIGMI, 2000.-204p.

13. Information Notes from Investigations Conducted by KAZGIDROMET, KAZNIIEKOM and RK Institute of Space Studies.

14. http://www.meteo.kz/monitoring.php.

15. Kurbanmuradov O., Ranmik U., Sabelfeld K. and Vesala T Stochastic Lagrangian Footprint calculations over a surface with an abrupt change of roughness height. Monte Carlo Methods and Appl.Vol.9, No. 1, 2003, 77-85 p.

16. Kurbanmuradov O., Ranmik U., Sabelfeld K. and Vesala T. Estimation of mean concentration and fluxes by Lagrangian Stochastic Medels. "Mathematics and Computers in Simulation". Vol.54, No. 6, 549-475, 2001.

17. GEO-2000, UNEP-2000; GEO-3, UNEP-2002.

18. GEO-3, national papers from Central Asian countries 1972-2002, Ashgabat, 2001.

19. Statistical Collections of the Republic ofTajikistan for 2000-2005.

20. Plan of Action on Environment Protection in the Republic of Tajikistan "Air Pollution". Dushanbe. 2001.

21. D. Kim. Aerosol Radioactive Forcing. – Shanghai, ABC Meeting, Oct. 7, 2004.

APPENDIX

Lidar Station Teploklyuchenka of the Kyrgyz-Russian Slav University is located in Kyrgyzstan at a height of 2000m above sea level in the south-east of the high-mountain Issyk-Kul Lake *(Fig. 15)*, Central Tien-Shan (42.5° N., 78.4° E.). The station was set up in 1987 for integrated monitoring of the troposphere and stratosphere aerosol in Central Asia *[4-7]*. In 2004 it was included into the international lidar net of the Commonwealth of Independent Countries – ***CIS-LiNET***.

MultibandLidar is operated in the following modes:

- observation of radiation intensities scattered back to the receiver at three wavelengths (355, 532 and 1064nm) and Ramanov backscattering with atmospheric nitrogen (387 nm) in an analog regime and in a regime of photon counting;
- observation of two perpendicular components of polarization of a signal of radiation scattered back in wavelength 532 nm with application of the Wollaston prism as a polarizer.

Main tasks of the Lidar Station Teploklyuchenka.

- studies of optics and microphysics of aerosol;
- development of regional aerosol models;
- studies of optical and microphysical properties of the Atmospheric Brown Cloud, dust and salt storms;
- investigation of the effect of an aerosol factor on glacier thawing in the Central Asian region.

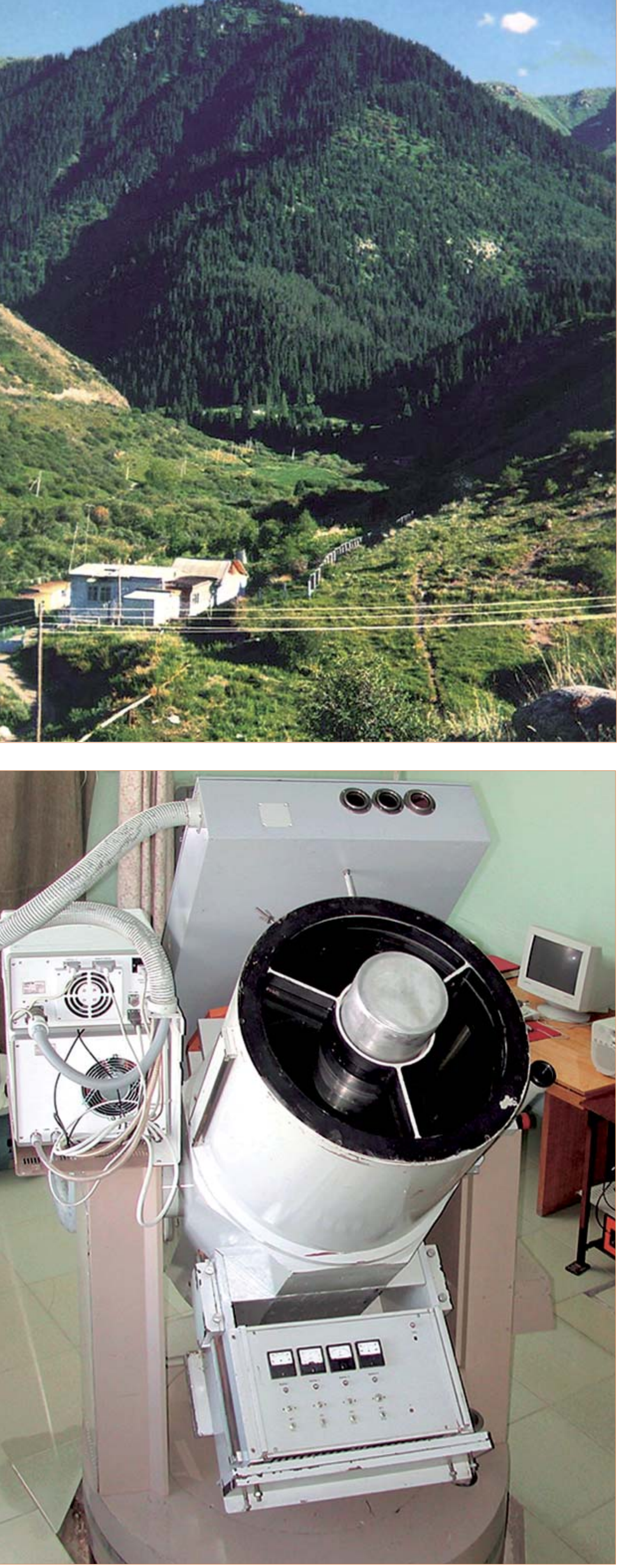

Fig. 15. Lidar station Teploklyuchenka (above) and Lidar complex (below).

INTEGRATED MANAGEMENT OF CHEMICALS IN CENTRAL ASIAN COUNTRIES

Contents

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1. Priority Rationale

Integrated management of chemicals is serious issue for contemporary world. In view of wide application of chemicals in production and every life, and their pernicious influence on environment and human health, the "Agenda 21 "was adopted at the 1992 UN Conference. Chapter 19 of this document named "Environmentally safe chemicals management, including prevention of illegal international transportations of toxic and hazardous products." has indicated main objectives and priority course of realization of actions in the field of optimization of chemicals management and utilization.

In order to coordinate measures taken at the national, regional and global levels, the Intergovernmental Forum on Chemical Security (IFCS) was established in 1994. The main objectives of the Forum were – establishing the actions priority, complex and agreed policy development in providing environmentally safe management of chemicals. Such global international legal documents as Basel Convention on the Control of Transboundary Movements of Hazardous wastes and their Disposal, Stockholm Convention on Persistent Organic Pollutants (POP), Rotterdam Convention on procedure of obtaining prior agreement concerning certain hazardous chemical agents and pesticides in international trade, Vienna for the Protection of the Ozone Layer and its Montreal protocol – have been taken as the principles of IFCS activity. In order to coordinate actions in the fields of chemicals management, in 1995 the FAO, OECD, ILO, UNDO, UNEP and WHO established the Interorganizational Program for Safe Management of Chemicals (IOMC).

Bai Declaration and "Priorities for Actions after the Year of 2000", was adopted at the IFCS 3rd Forum in 2000.

UN Environment and Development Conference "Rio+10", held in Johannesburg in 2002, confirmed its adherence to the principles of "Agenda 21 "by proclaiming "prevention negative effect of chemicals on environment and people" as its goal in the field of protecting safe utilization of chemicals till 2020. In order to practically realize Johannesburg Summit's objectives, the Strategic Approach for International Control of Chemicals' Management (SAICM) under the auspices of IOMC, UNDP, IFSC, UNEP, WHO, FAO and UNDO has been developed. The global objectives of strategic approach are to achieve reasonable utilization of chemicals during their effective life, so that essential negative effects of the production and utilization of chemicals on people and environment will be minimized up to 2020. One of the key provisions of SAICM strategy is to workout the complex agreed approach ***to the national control of chemicals and chemical waste products***, which could be achieved through development of the national programs.

Achieving the national management of chemicals will promote their control at the sub-regional level, which is subject of the present Assessment report.

2. State of the problem in sub-region of Central Asia

A. Ecological consequences of chemicals' production and utilization

Kazakhstan

Chemicals are produced at the enterprises of oil-refining, mining and smelting, chemical, construction and pharmaceutical industries. Minerals are the sources of their production. *(Table 1).*

Country's enterprises use a wide variety of chemicals (acids and alkalis, solvents, dyes and etc). In export structure the gas, oil-refining products, sulfuric acid, yellow phosphorus and its compounds, chemical fertilizers, chrome compounds are prevailing. Mainly exported products are plant chemicals and industrial chemicals. *(Table 2).*

A. Persistent, capable of bioaccumulation and toxicant[1] Agriculture is facing a critical problem of obsolete and unusable pesticides and their chemical identification. The 2003-2004 years' inventory within the UNDP/GEF project "Initial help to the RK in fulfillment of commitments of Stockholm Convention on persistent organic pollutants", carried out on the 20% of the country's territory has ascertained that there are over 1500 tones of such pesticides and their mixtures in storage facilities and repositories. Buried pesticides have to be extracted and annihilated. Besides pesticides themselves, there is a problem of utilization of their packages (over 330 thousand units).

B. Highly persistent and capable of bioaccumulation in large-scale chemicals are prohibited and limited in use.

C. Substances with carcinogenic and mutagenic characteristics, or substances with serious fatal affect to the human health, especially on reproduc-

[1] Group of chemicals is marked in accordance with the classification, used in Global Action Plan for Strategic Approach to the International Management of Chemicals (2006).

Table 1. Production, export and import volumes of minerals, thousand tons (2004)

	Production	Export	Import
Power engineering			
Coal	82 948,6	24 338 582,5	459 611,5
Lignite (brown coal)	3 873,2	222 875	346,6
Crude oil	50 581,8	47 742,93	3 250,1
Associated petroleum gas	10 264,5	–	–
Natural gas in gaseous state	9 616,9	14 340,8	9 219,5
Gas condensate	8 810,3	4 676 415,4	–
Chemical industry			
Phosphorite ore	–	–	–
Chrome ore	–	–	–
Common salt	–	–	–
Building materials industry			
Asbestos	200,0	183,0	17,0

Table 2. Chemical production/products and trade /2004/ *(Source: Statistics data - Republic of Kazakhstan)*

Oil products, thousand tones

Item	Production	Export	Import
Engine fuel (Petrol, including aviation fuel)	1 926,0	338 441,5	804 126,7
Kerosene, including jet engine temperature 150-300º C), thous	293,4	159 385,8	208 813,7
Gas oil (diesel oil), thousand t	2 886,6	911 993,2	524 641,3
Fuel oil	2 741,2	883 092,9	196 173,6
Motor oil, compressor lubricant, turbine lubricanting oil	–	227,8	110 268,4
Liquids for hydraulic purpose	0	0	8 899,2
Hydrocarbon liquefied gases	380,7	304,0	0
Propane	N/A	14 125,6	2 677, 6
Butane	–//–	311,7	1,2
Petroleum coke, petroleum bi oil-products processing	231,8	248,8	240,4
Coke and semicoke of black	2 658,2	975,8	872,3

Chemicals, tones

Item	Production	Export	Import
Carbon dioxide	5 838,0	0	3 546,2
Chrome oxide	20 302,0	38 910,7	346.2
Chrome sulfate	22953,0	22 554,7	1 202,0
Sodium bichromate	68 716,0	27 410,7	0
Chlorine	649,0	0	5482,4
Phosphorus	81 042,0	70 985,1	0
Sulfuric acid in monohydrate	745 003,0	30 525,2	352,5
Battery sulfuric acid	320,0	0	0
Orthophosphoric acid (phosphoric) and polyphosphoric acids	29 422,0	6 916,4	118,6
Nitric acid	0	0	13 397,2
Hydrogen fluoride (hydrofluoric acid)	6 083,0	3 783,9	0
Sodium triphosphate (Sodiutr)	29 594,0	30 865,0	118,4
Sodium sulfide	0	2 267,8	3 813,0
Calcium carbides	53 325,0	45 876,3	156,8
Anhydrous ammonia	46 679,0	191,6	18 190,2
Ammonia in water solution	0	0	1 305,2
Ammonium nitrate	0	0	216 413,9
Nitric fertilizers	94 669,0	0	10 051,1
Phosphate fertilizers	85 434,0	28 751,9	–
Ethylene polymers in primary forms	75,0	0	0
Styrene polymers in primary forms	474,0	27,4	80,8
Polyurethanes in primary forms	339,0	0	11,9
Pesticides and agrochemical products	2 044,0		16 704,2
Paints and varnishes based on polymers	14 123,0	26,6	27 355,2
Pharmaceutical medications, thousand dollars	28 053,0	–	–
Soap, substances and surfactant organic preparations	13 910,0	6 804,0	41 553,2
Detergents	3 070,0	4 042,7	75 481,2
Cleaning paste, powders and other cleansers	111, 4	0,2	3, 8
Shampoo, hair sprays, hairdressing and hair arranging preparations	3,404	568,7	10 426,9
Cement, building mortars and concrete additives	61,6	–	–

tive, endocrine, immune or nervous systems are prohibited and limited in use.

D. Persistent organic pollutants (POP). There is no production of POP. Main pollution sources are pesticides with POP properties in agriculture; equipment containing POP; in industries using technologies, which are inducing to dioxins and furans' unpremeditated emission.

In 20% of the country's territory, inventoried in 2003-2004, approximately 150 tones of pesticides with POP properties were found.

PCDs have been used from 1958 till 1990 in Ust-Kamenogorsk capacitor factory, as the liquid for filling the capacitors. At present there were found out PCD-containing equipment in quantity of 116 transformers and about 50 capacitors, mostly produced by this factory. PCD reserves contained in equipment are estimated at about 980 tones. Total reserves of PCD-containing waste products, are estimated at about 250 thousand tones. In their resources, Republic of Kazakhstan ranks second place among Eastern and Central European countries after the Russian Federation. 8 focuses of PCD-polluted territories were detected. Studies of congenital malformations' frequency and structure, ratio of underweight and overweight children, sex ratio in advantage of girls in one of such focuses (settlement Ablaketka, Ust-Kamenogorsk capacitor factory) demonstrate the effect of PCD on people's population.

Dioxins and furans' emissions in Kazakhstan in 2002, according to UNEP Chemicals technique, are preliminary estimated at 340 g-TE/per year.

E. Mercury and other chemicals, which are subject of global concern. Elimination of mercury pollution is one of the priority issues.

Chlorine-alkaline production in the Pavlodar Industrial Association "Chimprom" emitted 1310 tones of mercury metal and mercury salts. Nowadays, the first step of complex demercuration works has been carried out at the factory.

The Joint stock company "Qarbid" (Temirtau town) industrial platform for production of acetaldehyde also became a source of widespread of mercury. Most of various forms of mercury fall into Nuru River with sewages, discharged through filtering fields,

Table 3. Chemical production output

Chemical production products and their use	Year		
	2002	2003	2004
Production			
Phosphor, t	45 330	61 410	81 042
Orthophosphoric acid (phosphoric) and polyphosphoric acids, thousand tons	43	41	29
Chrome trioxide (chrome anhydrite) tons	14 539	19 911	19 814
Chrome tanning agent, tons	19 992	24 160	22 953
Sodium dichromate (sodium bichromate) tons	54 211	69 318	68 716
Chrome oxide, tons	11 527	15 346	20 302
Mineral or chemical fertilizers, nitrogen fertilizers, except fertilizers in tablets or similar forms and packages, not more than 10 kg thousand weight	17	28	95
Use			
Styrene polymer in initial forms, tons	8 730	4 073	399
Chlorine, tons	636	612	655

and further through industrial and domestic sewage disposal plants for 30 km of the river are highly polluted. According to demercuration project, the mercury will be extracted out of Nuru by the beginning of 2008.

F. Chemicals produced or used in large quantities. Over 200 of Kazakhstan's oil and gas fields have 2.2 billion tones of mineable reserves and 700 million tones of condensate. *(Table.3)*. Probable oil reserves of the country are estimated at about 13 billion tones of oil.

Main sources of oil pollution are the processes of surveying, production, primary refinery, transportation and application of oil products. On each step of development of oil fields asphalt-tar-wax containing sediments are generated.

The problem of over 10 thousand suspended and abandoned oil wells remains as the most serious issue. Idle oil wells, in flooded zones in the Caspian Sea are of particular danger. They continue gassing, including hydrogen sulfide. Conservation period of these oil fields has expired long time ago (over 20 years), and it is possible, that they could provoke extremely hazardous situation in the sea area at any time. The "Resource Development program of the mineral and raw materials complex of the state for 2003-2010" was approved by the regulation #1449 of the Government of Republic of Kazakhstan dated 29th December, 2002. The Program includes measures for elimination of 53 oil wells on land and 79 in the flooded areas of the Caspian Sea in 2006-2010.

Explored reserves of natural gas amount to approximately 2-2.5 trillion m³. Potential resources of natural gas are estimated at 10 trillion m³. Karachaganak gas fields' approximate capacity is 70.4% of all reserves of free gas.

Table 3 displays amounts of other chemicals produced or used in big amounts.

Deeper processing of mineral is performed only with phosphor and chromium. Researches in 80-90 years of the 20th century (Soil science Institute of Academy of Science of KazSSR) have discovered the formation of fluorine biogeochemical anomalies in Djambul phosphorus and chromium factories area in Aktubinskiy ferroalloy factory area.

G. Those articles, forms of utilization of which suppose their wide application in dispersion conditions. Specificity of petroleum production lies in getting large quantity of sulfur, which is caught, utilized, and because of no demands for it, is just stored on the territory of enterprises, also may be hazardous for environment. On the territories of"Tengizshevroil","Aktobemunaygaz", "Qarachaganak", three leading oil companies, approximately 15-20 million tones of sulfur is being stored, mainly in clumpy form. Their open storage may create conditions for vital functioning of sulfur-bacteria, which produce sulfuric acid.

3. Other chemicals, which are subject of concern at the national level. Biochemical anomalies, as the results of emissions, discharges, wastes of minerals and metal-working industries, and metals' galvanic processing products, (lead, zinc, copper, cadmium, arsenic and others) arose around Joint-stock companies "Kazzinc",Telekey lead-zinc industrial complex, "Yuzhpolymetal" /Shymkent city/, "Ulbinskiy metallurgical", "Ust-Kamenogorskiy titanium-magnesium industrial complex", "Irtyshskiy polymetal industrial complex", "Leninogorsk polymetal industrial complex", public corporations "Kazakhstan aluminum", "Balhashcopper", "Zhezkazgansvetmed", "Mittal steel Temirtau, Aksuskiy and Aktubinskiy ferroalloy works, and "TNK" Kazchrome", Aktubinskiy chromic compounds (Cr^{+6}) works and others.

Kyrgyzstan

Chemicals are produced in oil-refining, mining and smelting, chemical, construction and pharmaceutical industries *(Table 4)*.

A. Persistent substances, capable of bioaccumulation and toxicants. At present utilization of pesticides has been abruptly decreased. In storage facilities there are 95 tones of outdated and unusable pesticides and their mixtures. 1877 tones of pesticides, earlier buried in two burials, have to be extracted and annihilated.

B. Persistent organic pollutants. Production of POP is null.

During inventory of POP in 2004, there were findings of 1655 tons of pesticides with POP properties. Among them 1643 tons are stored in burials.

PCD in industrial production was not used. Equipments containing PCD represent a problem. 789 capacitors filled with PCD of total weight 18 tons, have been found.

Evidence of high content of POP in breast milk of nursing mothers, growing rate of breast cancer, increase of congenital malformation of newborn babies, higher infant mortality – indicates the effect of POP on the population.

C. Mercury and other chemicals, which are subject of global concern. Waste products of metal mining industry are being serious threat for the people *(Table 5)*.

Chemical waste products in lesser scales, including hazardous ones, are formed due to some technological processes in mechanical engineering (galvanic production, etching, low-temperature solder and others) and light industry (alkalization, bleaching). According to environmental regulations, which are currently in use, hazardous waste products have to be harrowed in special ranges, but up to now such kinds of ranges are not arranged.

Amount of industrial waste products in some companies, besides metal mining industrial complex, accumulated at the end of 2003 was equal to: 1st class danger waste-382 kg, 2nd class danger waste – 6,304 kg, 3rd class danger waste – 265,926 kg and 4th class danger waste – 10,936 kg.

Tajikistan

In the structure of modern industry the non-ferrous metallurgy is predominating. Its volume in the total industrial production is 49,5%. It unites combined plants, without complete metallurgical cycle, which extract and produce concentrates, except Tajik aluminum plant and Joint ventures "Zeravshan". The largest non-ferrous metallurgy enterprises are Isfarinskiy hydrometallurgy-cal plant, Anzobskiy ore mining and processing enterprise, Adrasmanskiy ore mining and processing enterprise, Industrial Association "Vostokredmet", Leninabad industrial complex of less-common metals, Joint Tajik-Britain gold-mining company "Zevarshan", Joint stock company "Darvaz", Tajik aluminum plant, Takobskiy ore mining and processing enterprise. In these companies the overwhelming majority of equipment and technology for ore-dressing (except Tajik aluminum plant) is out-of-date and needs modernization. Aluminum production is the only source of perfluorocarbon emission..

Chemical industry is presented by 9 enterprises. Most waste producing among them are PJSC"Azot" producing carbamide and ammonia, and PJSC "Tajikhimprom", producing liquid chlorine, and household chemical goods. Toxic wastes produced during this process are stored in exhausted storage facilities and in companies' territory (Table 6).

Waste-producing fields of industry are mining and smelting and non-ferrous metallurgy. 90% of total produced waste products fall to their share. There are 22 tailing dumps, used for keeping waste products of plants, 52% of them are suspended. Industrial waste products of different toxicity, generated at enterprises, which don't possess their special burying places, are taken out to municipal dumps of hard household waste.

Environmentally hazardous transboundary sources of chemical pollution through water bodies are: slimes of antimonies-mercury compounds from Anzobskiy SCIC – to confluent of Zeravshan-river, JSOC "Bekabadnerud" (Uzbekistan) metallurgic plant's waste – in Syrdarya-river, emission of anhydrous hydrogen fluoride from Tajik aluminum plant.

Turkmenistan

Chemicals are produced at enterprises of oil-refining, chemical, pharmaceutical, construction industries. Main Types of chemical products are oil-refining products (petrol, kerosene, diesel oil, motor oil), mineral fertilizers, (nitrogen, carbamide), sulfuric acid, iodine, bromine, technical carbon, sulfur, common

Table 4. Production, export and import volume of chemicals, thousand tons (2003)

Mineral	Production	Export	Import
Power engineering			
Coal	413,3	–	–
Crude oil	69,5	–	–
Oil products, including:	86,8 (86,9)	137,346	514,138
Benzine	25,0	–	–
Gas oil	22,0 (21,9)	–	–
Mazut	39,9	–	–
Industrial gas, thousand m^3	12152,0	–	–
Industrial chemical agents			
Inorganic	0,26	3,5	37,0
Organic	6,0	0,01	1,9
Dye and tanning	3,0	0,5	7,7
Pharmaceutical products, thousand som[1]	6973,9	0,002	2,3856
Household	1,54	0,4	24,2
Others	0,4	0,34	6,1
Lime	8,8	–	–
Cement	757,3	–	–
Asphalt concrete	157,9	–	–
Soap, detergent and cleaners	1,4	–	–
Perfumery and toiletry preparation	0,13	–	–
Chemical fertilizers	–	–	44,6
Pesticides	–	–	0,17
Sulphuric acid	–	–	1,1
Sodium cyanide	–	–	1,4
Ammonia	–	–	0,3
Hydrochloric acid	–	–	0,1
Mercury	0,55	–	–
Metal antimony	6,0	–	–

[1]Som- monetary unit

Table 5. Waste products of mining and smelting companies and related risk factors.

Type (place of warehousing, quantity)	**Waste volume, million m^3**	**Risk factor**
Tailing pits of enterprises of non-ferrous metallurgy and gold-mining (Sumsar – 3, Kann – 1, Khaidarkan – 1, Kadamjai – 2, Orlovka – 2, Ak-Tyuz – 4, Terek-Sai – 3, Kazarman – 1, Kumtor – 1) – **18 objects**	56,0	Mercury, lead, cadmium, arsenic, cyanides and other dangerous for human health heavy metals, inorganic acids and compounds. Pollution of atmospheric air, soils of adjacent territories, ground and / or surface waters is possible.
Industrial sewage ponds, salt and slurry ponds (Khaidarkan – 1, Kadamjai – 1, Orlovka – 1, Chauvai – 1) – **4 objects**	3,0	Contain mercury, arsenic, thorium-bearing compounds and other, inorganic acids and compounds. Pollution of ground and / or surface waters is possible.

Table 6. Raw materials' production and products made on their basis (2004) *(Source: Year-book of Republic of Tajikistan, Dushanbe, 2005).*

Item	Production
Oil (including gas condensate) thousand tons	18,6
Gas, million m^3	35,6
Coal, thousand tons	92,2
Hydrate of sodium	3,0
Chemical fertilizers (in converting to 100% of nutritive material),* thousand tons	40,0
Carbamide, thousand tons	87,1
Synthetic ammonia, thousand tons	54,6
Paintwork materials, tons	585,0
Cement**, thousand tons	193,6
Asbestos-cement sheets (roofing slate) million of provisional sheets	0,6

* productive capacity of enterprises is used up to 80.7%
** productive capacity of enterprises is used up to 34.7%

Table 7. Chemicals production volumes *(Source: Socio-economic Situation in Turkmenistan for 2005)*

Name	Year		
	2004	2005	Export
Oil products			
Oil, including gas, condensate, thousand tons	9601.9	9522.1	–
Gas, billion m^3	58.6	63.0	45.2(2005)
Oil refining, thousand tons	6 718,7	6 874,5	–
Motor gasoline, thousand tons	1 672,6	1 677,6	–
Kerosene, thousand tons	–	487,0	–
Diesel oil, thousand tons	1 803,1	1 842,6	–
Lubricating oil, thousand tons	50,8	51,2	–
Polypropylene, thousand tons	86,0	81,4	–
Liquefied hydrocarbon gas, thousand tons	359,0	395,6	–
Industrial carbon	–	2 232,0	–
Chemicals			
Industrial iodine	406	403	–
Chemical fertilizers, thousand tons	563,5	649,4	–
including nitrogen	–	402,4	–
phosphoric	–	402,4	–
Enriched kaolin, tons	1539	1693	–
Carbon, thousand m^3	–	41.7	–

and potassium salt, sodium sulfate, magnesium salt, ozokerite, by-schofite, detergents *(Table 7)*.

A. Persistent organic pollutants. (POP). Information regarding the POP in the country is not available.

B. Mercury and other chemicals, which are of global concern. There are no chemicals of such concern on a global scale.

Uzbekistan

Environmental problems, caused by chemicals, are presented by large territorial-industrial complexes – Angren-Almalykskiy, Chirchikskiy, Navooyskiy, Fergano-Margelanskiy Here were developed mining and smelting, chemical, oil-refining industries, as well as mechanical engineering and construction industries. Industrial production volumes are given in *Table 8*.

Main types of chemical products are sulfuric acid, ammonia, crops protection chemicals, and mineral fertilizers. The wide variety of chemicals is used in the factories (acids and alkalis, solvents, dyes and others).

A. Persistent toxicants, capable of bioaccumulation. Wastes management of outdated and useless pesticides is the main problem of agriculture. More than 1500 tons of such pesticides and their mixtures are stored in warehouses and storages, it is necessary to withdraw and destroy pesticides earlier buried in 13 burials; their total amount being 17718 tons. Some of them were built more than 40 years back and are becoming dangerous for the people and environment because of theirs destruction due to the impact of atmospheric precipitations and due to mud flows and in conditions of seismicity.

B. Very persistent chemicals, capable of bioaccumulation in very large amounts. Prohibited or limited in application.

C. Substances with carcinogenic and mutagenic characteristics, or substances with serious negative effect on the human health, especially on reproductive, endocrine, immune or nervous systems. Prohibited or limited in application.

D. Persistent organic pollutants (POP). POPs are not produced. According to the preliminary inventory of 2001, the total amount of pesticides with POP properties equals to 118 tons. The territories of former airports of agricultural aviation are the source of POP. Their total area is 4500 hectares.

PCDs were used as the components of the motor oils in transformers production (Chirchik town). Remains of off-test oils (sovtol) are kept in the warehouse of the mill. Medical checks of women of Karakalpakstan have revealed high level of some persistent organic pollutants, including dioxin in the maternal bloods, blood of umbilical cords and in breast milk.

E. Mercury and other chemical theat is a subject of concern on a global scale. Mountains, located on the border between Uzbekistan and Kyrgyzstan are rich with reserves of metals, such as silver, copper, antimony, and molybdenum – all together about 100 elements. For more than 50 years the excavation of valuable rocks has been taking place here. Even in 1990s this territory was polluted with heavy metals. Mercury emission in Haydarkan Mercury plant (on the territory of Kyrgyz Republic) equaled to 13 tons per annum. Big number of dumps, sludge collectors and tail-dumps are still there. Rivers beginning from these mountains are linked with Syrdarya River's basin and fully used for irrigation. Increased concentration of mercury in these rivers is mainly due to natural geochemical background.

Toxic wastes of enterprises garbage dumps, containing used mercury lamps cause serious concern and a number of factories for demercuration of mercury lamps function in the region.

Comments and conclusions. At present it is not possible to obtain enough information about production and use of chemicals in Central Asian subregion. Available data is related only to some types of chemicals (pesticides, combustive-lubricating materials), and does not provide complete idea about their volume and assortment. Development of systems of data collection, provision and distribution, setting up of national register of potentially hazardous chemicals will provide the opportunity to obtain necessary data for improvement of management system of chemicals' handing and decision basing for prevention of their negative influence on human

Table 8. Industrial production volumes, thousand tons (2004) *(Sources: Statistics of Republic of Uzbekistan)*

Industrial sector	Production
Power engineering	
Coal (total)	2699,0
Coal	58,0
Brown coal	2641,0
Oil including gas condensate	6616,8
Initial oil refining	5618,1
Natural gas, billion m^3	60,4
Mechanical engineering	
Power transformers, thousand kW	324,6
Accumulators, thousand pcs	84,7
Motor vehicles	70,3
Building materials industry	
Cement	4804,8

Table 9. Production of chemicals (2004) *(Source: Statistic Digest of Republic of Uzbekistan)*

Item	Production
Sulphuric accumulator acid	–
Sulphuric acid in monohydrate	834,3
Synthetic ammonia	1019,1
Chemical fertilizers	875,7
Nitrogen fertilizer	736,1
Phosphoric fertilizer	139,6
Plants protective chemicals (pesticides)	5241,0
Fibers and their chemical threads Synthetic fibers and threads Plastic goods	9,2 8,6 2,0
Production of synthetic resins and plastic mixture	112,2

health and environment. However, countries are facing the scarcity of resources, which are necessary to perform the chemicals evaluation, for which relevant data is available.

Differences between countries in identification of priority ecological problems related to chemicals could be due to of the share of industrial sector in the countries and due to specifics of local conditions. In Kazakhstan these are problems related to production of minerals and activity of defense enterprises. Kazakhstan and Uzbekistan should resolve the problem through reconstruction of territories polluted with PCD as a result of filling condensates with trichlordiphenyls in the past – by Ust-Kamenogorsk condensate plant and Chirchik transformers plant.

Rehabilitation of territories polluted with pesticides at former airfields of agricultural is an urgent aviation problem for Uzbekistan, Kyrgyzstan and Tajikistan.

Outdated and pesticides useless in agriculture are main sources of chemical pollution in Central Asian countries.

Chemicals of Group B ("very persistent chemicals, capable of bioaccumulation in very large scales") and Group C ("substances with carcinogenic and mutagenic characteristics, or substances with pernicious influence on human health, especially on reproductive, endocrine, immune or nervous systems") are prohibited or limited for use in agriculture. The State Roster of prohibited or limited-in-use active and not-active ingredients of materials for crops protection is kept in the countries. The substances with characteristics pointed out in items B and C, as well as compounds of the group of persistent organic pollutants (POP) were included into the Roster.

Substances with carcinogenic and mutagenic characteristics or substances with pernicious influence on human health, especially on reproductive, endocrine, immune or nervous systems are not allowed to be registration. Thus, chemicals, consisting of such active ingredients as endosulphan, phipronyl, benomyl, with properties of substances of Group C were not allowed for registration in the State Chemical Commissions of Central Asian countries.

Use of equipment containing polychlordifenils (PCD) and obsolete technologies in the industry, which leads to emission of dioxins and furans – is the common characteristic of sub-region countries.

Due to above-mentioned, the monotype priorities are identified for all Central Asian countries:

A. Elimination of outdated and useless pesticides (including pesticides with POP characteristics), stored in the warehouses and buried in mortuaries.
B. Elimination of PCD containing equipment.
C. Reconstruction of territories polluted with POP.
D. Reconstruction of territories polluted with heavy metals.
E. Use of technologies with minimum emission of dioxins and furans.

The trans-boundary problems are also urgent in the sub-region. There is need to arrange monitoring of organic combinations in the air, which are listed in Stockholm Convention on POP, and volatile organic combinations. This will be in accordance with the content of the same-name Protocol to the Convention on trans-boundary long-range air pollution.

B. Current situation in the issues of integrated chemicals management

Current situation in the integrated chemicals management has got different aspects of consideration: strategic, inter-sector, and departmental interaction, and procedural-legislative.

1. Strategic measures, which are implemented or under implementation, aimed at the integrated chemicals management

Strategic documents, important in principle from the point of chemicals management, have been adopted or presently under consideration in the Central Asian countries.

Central Asian countries

On the global level some of sub-region countries are members of the UN Commission on Sustainable Development (Kazakhstan, Uzbekistan)..

At the regional level CA countries are involved into the process "Environment for Europe". Since 2003 Kazakhstan is also a member of regional Eurasian network of the World Council of Entrepreneurs for Sustainable Developments.

At the sub-regional level CA countries are participating in realization of the Regional Environmental Action Plan and in preparation of the Framework Convention on Environment for Sustainable Development of Central Asian countries, and actively supporting the process of preparing the Central Asian Strategy for Sustainable Development (Sub-regional Agenda-21).

Kazakhstan

National documents pursuing objectives of sustainable development of the country:

1. Strategy of Development of Kazakhstan till 2030 – "Kazakhstan-2030".
2. Message of President of the country to the people of Kazakhstan on March 1, 2006 – Strategy of Kazakhstan for ranking among 50 most competitive countries of the world.
3. Strategy of industrial-innovative development till 2015.
4. "Concept of transit of Republic of Kazakhstan to sustainable development for 2007 – 2024" (approved by the Decree of President of Republic of Kazakhstan dated 14 November # 216).

Measures pursuing objectives of sustainable development of the country:

- the Council for Sustainable Development of Republic of Kazakhstan was established (2004);
- the Sustainable Development Fund of Republic of Kazakhstan "Kazyna" (2006) was established.

National strategic documents, which include issues of integrated chemicals management:

1. Strategy of Ecological security of Republic of Kazakhstan till 2015.
2. Environment Protection Program of Republic of Kazakhstan for the period of 2007-2010.

Kyrgyzstan

National documents pursuing objectives of sustainable development of the country:

1. Complex Bases for Development of Kyrgyz Republic till 2010. Nationwide Strategy. Bishkek, 2002..
2. National Strategy for Poverty Reduction in Kyrgyz Republic, 2002.
3. Strategy for Sustainable Development of Kyrgyz Republic, 1997.

National strategic documents, which include issues of integrated chemicals management:

1. Agenda 21 of Kyrgyz Republic. Bishkek, 2002.

Tajikistan

National documents pursuing objectives of sustainable development of the country:

1. Needs assessment for achievement of Goals of Millennium Development 2005.

National strategic documents, which include issues of integrated chemicals management:

1. National Action Plan of RT to mitigate sequences of climate change, 2003..
2. National Program to Stop the Use of Ozone Level Depleting Substances, 2002.
3. National Environmental Action Plan of Republic of Tajikistan for the period till 2009..

Turkmenistan

National documents pursuing objectives of sustainable development of the country:

1. "Strategy of Socio-economic Reforms in Turkmenistan for the Period till 2010".

National level measures meeting objectives of integrated production and chemicals management.

Under the Decree of the President of Turkmenistan No.4091 dated March 1,1999. the State Commission for Ensuring Fulfillment of Turkmenistan's Obligations Ensuing from Environmental Conventions and UN Programs

Uzbekistan

National strategic documents, which include issues of integrated chemicals management:

1. "Action Environmental Program of Republic of Uzbekistan for the Period 2006-2010" in the stage of approval

National level measures meeting objectives of integrated chemicals management. The most important strategic trend concerning chemicals is the application of relatively pollution-free types of fuel, especially in transport (substitution of petrol with gas, electrification of railway roads).

With financial support of UNEP and UNDP a number of International ecological projects has been implemented in Uzbekistan, particularly, the Center of clean production has been set up in Tashkent. Its aim is to increase economic productivity and improvement of ecological requirements in industrial sector of Uzbekistan.

2. The Role of Government Structures of Central Asia in Resolution of Problems of Management of Chemicals' Life-cycle.

The authorities of governmental organizations, which are dealing and responsible for different aspects of chemicals management, according to the current legislature, are generally the same in different countries, but there are some differences as well.

The role of ministries and departments of Environment protection is the same: transportation>use>circulati on>rejection>eli mination.

The chemicals life-cycle management in agricultural sector includes import>storage>transportation>ma rking/distribution (except for Republic of Uzbekistan) >use> circulation>rejection.

In Health care sector the chemicals life cycle is under control starting from storage and ending with disposal. The issues of labor safety are under control through out all stages of chemicals life cycle.

In industry, due to wide spectrum of activity (industry in general, energy sector, gas industry, mineral resources, trade, transport, construction), in each factory there are different stages of life-cycle, but generally the sectoral ministries keep track of chemicals through out their life-cycle.

Participation of Education and Science ministries considered only in regard to searching of new technologies for elimination of chemicals and their use/ circulation (Republic of Uzbekistan).

Functions of interior and defense ministries are related to storage>use/circulation>rejecting to waste; ministries for extraordinary situations are involved in the stage of elimination.

Custom departments deal with chemicals in import and export stages.

Obligations of relevant ministries, government agencies and departments, related to the problem of integrated chemicals management, are based on special regulations related to instructions on certain types of chemicals (for example, pesticides, transportation of hazardous goods, drugs, psychotropic drugs, medications, etc.). They are linked with type of their activity. Their functions and authorities directed to certain fields (for example, environment, health care).

In most of the cases functions, obligations and competence of different ministries and departments are replicated, there is a lack of coordination of their activity; different obligations on certain groups of chemicals results in dissociation in their actions, because each department cares only about those groups of chemicals which are under their competence. There is urgency for working out the Protocol of function sharing between state bodies in the field of chemicals management.

3. State of legislature and procedural-methodological base

In order to increase benefits and decrease expenditure, related to the use of chemicals, countries of Central Asia try to control them through working out relevant strategies, adopting legal acts, staff training and distribution of information.

State analysis of procedural-methodological base in this sphere in CA countries indicates the absence of a state system of chemicals management, which would include all components of the life cycle. Integrated approach to the chemicals management is not properly worked out in the countries of Central Asia.

Following laws regulate chemicals management in agricultural sector of CA countries:"0n protection of Agricultural Crops from Plant pests, Crops Illness and Weeds" (Uzbekistan),"On Plants Protection" (Uzbekistan, Kazakhstan).The Governmental Decrees "Statute on State Commission on Chemicals" (authorized body in the field of plants protection), "On Measures to Improve the System of Provision of Agricultural Sector with Chemicals for Protection of Crops" have been published in Uzbekistan.

However, these efforts are not effective enough due to absence of political obligations, lack of resources available, gaps in legislature, absence of inter-sector cooperation, poor observation of laws, limited training, etc.

Classification and marking the chemicals and keeping registers for wastes as an element of management are not matching the international standards. Soonest implementation of World Harmonized System of chemicals classification and marking and registers of wastes and migration of pollutants is seemed to be the first priority.

3. Indicators of integrated chemicals management

Each country of Central Asia, due to existing economical, social and ecological conditions, is participating in the process of international chemicals regulation. Success of these efforts could be estimated through obtaining of indicators for realization of integrated chemicals management.

Clear, concrete, convenient in work, informative and comprehensive indicators of successful realization of integrated chemicals management are in the stage of development. Indicators, contained in the *table 10*, should be considered from these positions.

4. Requirements in resolution of issues related to integrated chemicals management on the sub-regional level

1. Establishment of more effective governing structures for facilitating achievement of success in steady application of Strategic approach to the international coordination of chemicals management (SAICM):
   - development and improvement coordinated links between existing organizations, involved in the process of chemicals management with the aim of achieving the effect of synergism;
   - increase of opportunities for rational regulation of chemicals on the national, sub-regional, regional and global levels;
   - formation of resources for solution of chemical safety issues.

Due to the fact that chemicals are used in a number of sectors, related to different national ministries, available experience indicates on the necessity of having coordinating mechanism in the framework of sub-region.

Central Asia, which is the single natural, geographical and historical sub-region of the world formed by the countries with transitional economy, needs the **Center for regulation of chemicals to function (CA CRC).**

Its activities ideology should be based on practical implementation of ecological idea – to work for the future without borders, without chemicals, which are harmful to environment and human health, as well as establishment of institutional foundation for fulfillment of obligations of Central Asia under international chemical environmental conventions.

Management model of the Center should be based on the understanding the global hazard posed by chemicals, regardless of political or administrative borders and departmental interests, as well as on practical actions.

Principles of its activity should be stability, transparency, responsibility, professionalism, and reliability, intersectional and sub-regional interstate cooperation.

Its everyday activity should be based on combination of program (development of programs on interstate level – monitoring of chemicals, elimination of their intended wastes, introduction more non-polluting industry for the reduction of un-intended emission of chemicals, awareness, education and other projected approaches in project management.

The Center may have its branches or actively cooperate with existing or planned Centers in countries of the sub-region.

The Center assumed to be an organization, which would provide technical and methodological and informational analytical assistance in the issues of chemicals circulation. It should be equipped with modern laboratory equipment able to conduct most precise analysis of very hazardous chemicals from whole sub-region, including high-costly analyses of dioxins and furans. There are no accredited international level laboratories in Central Asian countries.

In order to eliminate POP in accordance with requirements of Stockholm convention on POP, there is need for construction of modern utilization plant and provision of mobile installations of the same kind to execute immediate measures. After elimination of POP problem (after 2025) the POP plant and mobile installations may switch to the elimination of other extremely hazardous chemical wastes, such as medical and others. It is not improbable that this plant could expand area of its activity through assisting the elimination of most hazardous wastes of neighboring countries of Southeast and Middle Asia.

2. Reduction of risks (including prevention, reduction, abatement of sequences, minimization of the risks and their elimination):

- development of evaluation strategy and risk regulation, based on more comprehensive scientific understanding of roles and origin of substances, particularly the life-cycle of the products;
- risk reduction measures, well-grounded with use of scientific methods and factors, including social and economical considerations;
- improvement of risk reduction measures in order to prevent negative effect of chemicals on vulnerable groups of population and environment sensitive to these substances;
- facilitation of implementation of safer technologies and alternatives.

With this purpose it is necessary to establish (where they are not available) and develop or strengthen, as necessary, the network of centers for implementing measures in extraordinary situations, including toxicological control centers.

3. Ratification and implementation of global and regional agreements, related with chemical aspects of environment, health care, security, hygiene and labor protection. The lack of involvement of social conventions for integrated chemicals management (except for Kazakhstan) deserves attention. However, none of the countries of Central Asia has ratified the most significant ILO conventions in this regard: # 170-"On safety of chemicals use in the industry" and Convention #174 "On prevention of large-scale industrial accidents".

4. Development of national directive documents on the issues of chemicals management, insertion of chemicals regulation issues into the plans and development strategies and other relevant initiatives.

5. Capacity building and technical facilitation in all aspects of rational chemicals regulation.

6. Development of measures, dealing with illegal turnover of hazardous substances and products.

7. Implementation of measures, encouraging use of existing internationally acknowledged standards, mechanisms and approaches, used in the context of environment and health care, as well as protection

Table 10. Indicators of implementation of integrated chemical agents management in Central Asian countries

1. Realization of Strategic approach towards international regulation of chemical agents

	Страна				
Indicator	**Kazakhstan**	**Kyrgyzstan**	**Tajikistan**	**Turkmenistan**	**Узбекистан**
1	2	3	4	5	6
National Coordinator SAICM/ - name of concern official	Documents for Vice-minister of environment protection, dealing with international cooperation issues, have been prepared	Not appointed	Not appointed	Not appointed	Not appointed
Projects implemented under auspices of SAICM Quick Start Program	Projects of Quick Standard Program have been prepared, but are not under realization because the National Coordinator SAICM has not been appointed yet	Not implemented	Not implemented	Not implemented	Not implemented

2. State Managements; improvement of institutions, legislature and policy

1	2	3	4	5	6
National profile on rational use of chemical agents has been worked out and placed on web-site of the relevant coordinating department	National profile has been worked out in 2006 and placed on the Web-site www.nature.kz in the "Chemical security" section.	"National profile of Kyrgyz Republic for evaluation on national infrastructure on persistent organic pollutants management» was worked out in 2005 and placed on the Web-site www.pops.kg	Not prepared	Under preparation	Not prepared
World harmonized classification and marking system of chemical agents and emissions registers and pollutants transfer, in order to provide full usage of this system by 2008, has been introduced.	Not implemented	Not implemented	Not implemented	Not implemented	Not implemented
International environmental agreements (IEA) on chemical agents and hazardous wastes have been ratified and are being realized (date of ratification, capacity building activities in the line of fulfillment of obligations under IEA)			Action plan on national capacity building to fulfill the obligations of Tajikistan on global ecological conventions.		

Continuation of table 10. Indicators of implementation of integrated chemical agents management in Central Asian countries

Life cycles of rejection to wastes and elimination

Indicator	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Stockholm Convention on POP Indicator of fulfillment of obligations: Elimination of POP by 2025.	Convention is not ratified; Signed on behalf of Government of Kazakhstan on May 23, 2001	Convention is ratified 13.06.2006; Kyrgyz Government on July 3, 2006, No. 371-p, approved National Executive Plan.	Convention is not ratified; Signed on behalf of Government of Tajikistan on May 21, 2002.	Not ratified	Not ratified

Life cycle of import, use and circulation

Indicator	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Rotterdam Convention on procedure of obtaining prior agreement concerning certain hazardous chemical agents and pesticides in international trade	Convention is not ratified	Convention is ratified on January 15, 2000.	Convention is not ratified	Not ratified	Not ratified
Convention on trans-boundary effect of industrial accidents	Law of RK № 91-II dated October 23, 2000	Not ratified	Not ratified	Not ratified	Not ratified
Convention on trans-boundary long range air pollution	Law of RK № 89-II dated October 23, 2000.	Convention was ratified. The law about joining № 11 dated 14.01.2000.	Not ratified	Not ratified	Not ratified
Convention on protection and use of trans-boundary watercourses and international lakes.	Law of RK № 94-II dated October 23, 2000.	Not ratified	Not ratified	Not ratified	Not ratified
Convention ILO, related to chemical agents	1. Law of RK №10-I dated June 26, 1996 "On protection of toilers from vocational risk caused by air pollution, noise and vibration on the working places". 2. Law of RK № 7-1 dated June 13, 1996 "On labors and industrial environments security and hygiene"	No data available	No data available	No data available	No data available

Continuation of table 10.

Transportation life cycle

1	2	3	4	5	6
Basel Convention on control over trans-boundary transportation of hazardous wastes and their disposal	Law of RK № 389-II dated February 10, 2003.	Convention ratified on November 30, 1995	Convention is not ratified	Ratified on June 18, 1996. Decree of Mejlis of Turkmenistan № 159-1	Ratified in 1995.
Framework UNO Convention on climate change	Ratified by Decree of President of Kazakhstan № 2660 on 4.05.1995 "About ratification of framework UNO Convention on climate change".	Convention ratified on January 15, 2003	Ratified in 1998.	Ratified on 05.06.1995.	Ratified on June 20, 1993
Kyoto Protocol	Kyoto Protocol signed in 1999, but not ratified.	Not ratified	Not ratified	Not ratified	Ratified on August 20, 1999
Vienna Convention on Ozone protection	Law of RK № 177-I, dated October 30, 1997.	Convention ratified on January 15, 2000.	Ratified in 1996	Ratified in November 1993	Ratified in 1993.
Montreal Protocol	Ratified in 2000.	Ratified in 2000.	Ratified in 1996.	Ratified in November 1993	Ratified on August 26, 2006.
London Amendment	Ratified in 2000	Ratified in 2000	Ratified in 1996.		Ratified in 1998

3. Widening of institutional potential

1	2	3	4	5	6
Systems of ecological management, based on international standards ISO 9000 и 14000, EMAS, BS 7750 implemented/are being implemented	The number of enterprises of Kazakhstan implemented Systems of Quality Management in compliance with ISO series 9000, has been increased from 5 in 2001 to almost 450 at present time, around 140 enterprises are about to implement, and 17 enterprises have certified their System of environment management on compliance with requirements of international standard ISO 14000 series.	2 enterprises	No enterprises	No enterprises	No enterprises

Continuation of table 10.

4. Measures Promoting the Risk Factor Reduction

1	2	3	4	5	6
System, oriented to prevent large-scale industrial accidents and systems for provision of readiness to extraordinary situations and response actions.	"Concept of prevention and elimination extraordinary situations of natural and man-made origin and improvement of the state system of management in this field". /Approved by Decree of the Government of Kazakhstan dated November 23, 2005, 1 1 54/.				1. Statute "On State system of prevention and actions on extraordinary situations of natural and industrial origin on the territory of the Republic of Uzbekistan". Decree of the Government of Uzbekistan dated December 23, 1997. 2. Concept and State program on forecast and prevention of extraordinary situations (on the stage of approval).
Prevention of illegal transportation of toxic and hazardous products has been worked out/under consideration	Under development	Not worked out	Not worked out	Not worked out	Decree of the Cabinet of Ministers of Uzbekistan № 151 dated April 19, 2000 "About regulation of importation to Uzbekistan and export from its territory ecologically hazardous products and wastes"
Poisoning control Center has been established	There is Medical disaster Center at the Ministry of health care of Republic of Kazakhstan.	Center is not established	Center is not established	Center is not established	Established at the Country's Center of emergency medical aid.
Initiatives on risk reduction as regards chemical agents, causing serious concern, have been put forward/are under implementation.	Projects of environment refinement from mercury pollution are implemented: 1. First stage of demercurization work has been done on Pavlodar Industrial Association "Chimprom". 2. In accordance with demercurization project on Joint-stock company "Qarbid" (Temirtau city), the mercury from Nury River will be extracted by early 2008. 3. "Resource development Program of the country's minerals and raw materials complex for the period 2003-2010" (approved by Kazakhstan's Government decree № 1449, dated December 29), According to Program there is plan to eliminate 53 oil wells on onshore and 79 wells in the Caspian Sea during 2006-2010.	Initiatives are not put forward	Initiatives are not put forward	Initiatives are not put forward	Initiatives are not put forward

Continuation of table 10.

1	2	3	4	5	6
5. Accumulation of new knowledge and information					
Efficient network of information exchange about capacity building with the objective of rational use of chemical agents	Not functioning	Not functioning	Not functioning	Not functioning	Not functioning

1	2	3	4	5	6
6. Improvement of general operation mode					
Protocol on register of potentially hazardous chemicals emission (Aarhus Convention on right of the public to have access to information) has been ratified and is being implemented.	Under implementation	Ratified			

from chemical impact, for example, globally coordinated system of chemicals classification and marking, as well as registers of pollutants emission and transfer.

8. Obtaining access to financial, technical and other resources, which are necessary for provision of rational chemicals regulation.

9. Creation of conditions for increase of knowledge, information and improvement of awareness for making decisions regarding rational chemicals regulation, including products and goods containing such chemicals:

- arrangements for access to technical information and stimulation of scientific research;
- arrangements for access of the local population to the information on chemicals.

5. Concept of project proposals related to issues of integrated chemicals management on the sub-regional level

1. To organize sub-regional partnership on development and realization of the strategy for elimination of particularly hazardous chemicals (POP, persistent, capable of bioaccumulation chemicals and toxicants; chemicals posing global concern) in whole Central Asian sub-region. Based on that partnership, it is possible to resolve all the problems of specifically hazardous chemicals circulation.

2. Taking into account the fact that on the global and regional levels up to ten international environmental agreements in the field of chemicals regulation are in function, it becomes essential to solve the problem of chemical conventions synergism, which will contribute to the improvement of integrated chemicals management.

3. It is important to organize interaction with other urgent sub-regional issue – monitoring of "Atmospheric brown cloud" and dust and salt transport. Results of resolution of this problem will be useful for a number of issues concerning the regulation of chemicals circulation, as well as the obtained results would be very important for research of natural cycles of aerosol migration.

4. In order to achieve rational regulation of chemicals and chemical wastes, a big attention is also paid to the fact of participation of all interested parties and establishment of state-to-private partnership.

6. Efficiency Evaluation

Secretariats of "chemical" conventions, each of them according to their list, carry out efficiency evaluation of the chemicals management. It is possible that such evaluation could be done on the national and regional levels as well. However, effectiveness of integrated approach towards the management of chemicals throughout their whole life cycle should be performed by an authorized body on the national level and by SAICM – on the international level.

Reduction of level of hazardous chemicals in components of environment and food products will indicate the proper management. If efficiency evaluation will indicate that risk of chemicals has not decreased enough, then further measures could be undertaken.

Efficiency evaluation should also cover issues related to the cost effectiveness of the undertaken measures. It should also include evaluation of the fact if the risk of hazardous chemicals reduces risk decrease in the course of financing the chosen approach the chosen approach and measures and actions.

Results of measures undertaken are presented in reports on execution efficiency. Scheme of presentation of reports on execution efficiency will be adopted in agreed order.

The issues of efficiency evaluation have been precisely worked out by the Secretariat of Stockholm Convention on POP, including methodology of evaluation, indicators of efficiency, spectrum of issues underestimation, monitoring, etc. Efficiency evaluation is conducted in accordance with time frame of holding the Conference of Parties. Experience of the Secretariat could be used for the purpose of efficiency evaluation of management of chemicals.

Table 11. Schedule of measures for implementing integrated management of chemicals in the countries of Central Asia

Measure	Responsible executor	Terms of execution	Financing source
Establishment of a Central Asian Center for regulation of chemicals (CA CRC).	UNEP, ICSD, environmental ministries and departments of CA	2007-2009	UNEP, co-financing of the countries of CA sub-region
Evaluation of potential of Central Asian region in realization of Strategic approach to international management of chemicals.	UNEP, ICSD, environmental ministries and departments ofCA andCACRC	2007-2009	UNEP
Establishment of»Guidance on integrated management of chemicals in CA countries".	UNEP, ICSD, CA CRC	2007-2008	UNEP, ICSD, CA states' Budgets
Establishment of Unified system of POP monitoring in CA.	CA CRC	2008-2010	CA CRC
Establishment of CA integrated sub-regional information network on chemicals.	UNEP, ICSD, CA CRC	2008-2010	CA CRC
Establishment of annual Roster of POP emissions in CA	CA CRC	from 2010 года	CA CRC
Establishment of a system of control over condition and storage of specially hazardous chemicals in CA	CA CRC	from 2010 года	CA CRC

Table 12. CA CRC budget (tentative)

A. Establishment of the Center of chemical safety in Central Asia:

Financial expenditure, US$	US$ per year
Salary	188 400
Tax	30 144
Business trip allowance	3 000
Equipment	20 000
Materials	2 000
Apartments rent	10 000
Telecommunication	1 000
Overhead expenses	5 000
Outside service	10 000
Direct expenses	10 000
Total	**279 544**

Salary, US$

Position	Number of employees	Monthly wage	Annual salary
Director	1	1500	18000
Deputy administrator	1	1000	12000
Experts	5	800	48000
Manager of laboratory	1	1000	12000
Research workers	2	800	19200
Laboratory assistants	2	400	9600
Training center manager	1	1000	12000
Teachers	4	800	38400
Accountant	1	1000	12000
Service staff	3	200	7200
Total per year			**188400**

B. Specially hazardous chemicals annihilation factory

#	Action	Cost, US$
1	Purchase of plant for burning the specially hazardous chemicals	50 000 000
2	Purchase of plant for chemical decomposition of POP	11 000 000

C. Establishment of dioxin laboratory

#	Action	Due date	Expenses US$	Responsible body	Executors
1	Establishment of dioxin laboratory.	2009	2 000 000	CA CRC	CA CRC
2	Monitoring and compiling the annual roster of dioxin and furans emission in CA	2010-2028	5 000 000	CA CRC	CA CRC

STABILITY OF MOUNTAIN LAKES IN CENTRAL ASIA. IMPACT RISKS & UNDERTAKING OF MEASURES

Contents

Assessment Report ***"Stability of Mountain Lakes in Central Asia: Impact Risks & Undertaking of Measures"*** has been prepared in accordance with the ICSD decision of 02 March, 2006 and results of the meeting of ministers of environment of Central Asian (CA) at the 9th ad hoc session of GEF Board of Directors assisted by UNEP and initiated by Mr. Surendra Shrestha (Director of UNEP Regional Resource Center for Asia and the Pacific (UNEP RRC. AC, Bangkok. Thailand).

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Photos made by N.R. Ischouk, A.R. Ischuk, Zh. Shneider, S.A. Erokhin, A. Khamidov and "Landsat"space images of 2001-2002 are used in the book.

Foreword

The goal of the report was to review the information on mountain lakes status, including lakes of breakthrough risk, conditions of their formation and preventive measures undertaken by CA countries for reduction of risk of their impact on environment and population, which were cited in numerous publications devoted to investigation of this problem. The necessity of investigating mountain lakes of breakthrough risk is of particular topicality due to the growing processes of climate change, glacial blanket degradation against active geodynamic processes taking place in mountainous territories of CA.

The CA mountains occupy nearly 20% of its territory and serve as a peculiar storage of over 60% of water resources in the form of ice and snow, and are a guarantee of conservation and rehabilitation of the landscape and biological variety. There are 5600 lakes with the total area of 12197 km^2 on the CA territory, the vast majority of them are located in the mountainous area of the region. The water resources of medium and small mountain lakes are estimated to be of 51.1 km-3, 20 km^3 of which relate to fresh waters.

Investigation of mountain lakes in CA has a one-century history, which in its turn was of episodic and unclustered character. Systematic study of breakthrough risk of CA mountain lakes started in 1960s and lasted till the USSR collapse. From the period of sovereignty declaration by CA countries, efforts for systemic investigations of mountain lakes have reduced – this mainly was due to extremely low level of financing of the state specialized institutions, responsible for monitoring of environment, and to flow-out of qualified in this field personnel.

Currently, there are no standard approaches in countries CA to studying of mountain lakes in the issues of their formation and potential danger. The researchers have got various classifications of mountain lakes, which are generally similar to each other, but differ in some prevailing factors and conditions of their formation. Moreover, a reliability of forecast of mountain lake further development and the undertaking of preventive actions depends on a right identification of the reason of mountain lake formation.

The necessity of investigation of mountain lakes of breakthrough risk is currently of great importance due to the growing processes of climate changes, and the glacial blanket degradation against active geodynamic processes being specific for the CA mountain areas.

The Governments of Kyrgyz Republic and Republic of Tajikistan for the development of recommendations to Agenda 21 have put forward an initiative and the UN General Assembly adopted relevant resolutions on proclaiming the year of 2002 as the "International Year of Mountains» and the year of 2003 as the 'International Year of Fresh Water 'The UN General Assembly also adopted a special resolution proclaiming the years of 2005-2015 period as the International Action Decade "Water for Life". This gives a powerful impulse for activation of activities for implementation of projects and programs related to comprehensive researches of development of mountainous territories.

Interest of international organizations in the issues of studying mountain lakes in Kyrgyzstan and Tajikistan has lately increased. However, assistance provided by international organizations for developing the strategy in the sphere of extraordinary situations is of unsteady character, and is mainly aimed at the response to the great natural disaster, which has already occurred, and provision of assistance in rehabilitation works.

An efficient solution of problems related to studying of mountain lakes of breakthrough risk, adjustment of mechanisms for their monitoring both at the national and regional levels require successive, purposeful and joint actions intended for the long prospects. They should unite efforts made by governments, civil community institutions, business circles, scientists, as well as to promote development of international collaboration.

The given Assessment Report has been published due to the initiative of Mr. Surendra Shrestha (Director of UNEP Regional Resource Center for Asia and the Pacific (UNEP RRC. AC, Bangkok. Thailand) and GEF financial support.

1. General characteristic of natural conditions of the region

CA occupies the area of about 4 mln sq.km, being located between latitude 35-550 North and longitude 48-870 East. CA includes: Republic of Kazakhstan, Kyrgyz Republic, Republic of Tajikistan, Turkmenistan, and Republic of Uzbekistan *(Fig.1)*. The CA total population amounts to about 59 mln people, with an average density approaching 15 persons per sq.km.

From the hypsometric point of view the CA territory is located at the range of 132 m below sea level (the Karagiye Depression in Western Kazakhstan) up to 7495 m above sea level (Ismoil Somoni Peak in Pamirs in Tajikistan).

Regarding the land surface structure 4/5 and 1/5 of its territory are covered with plains and mountains, respectively.

A landscape variety on the mountain territories complies with the vertical zoning. The mountain semi-deserts, mountain steppes, mountain forests, Alpine meadows and mountainous deserts and semi-deserts are common thereat.

The overwhelming part of water and power resources is formed in CA mountainous area.

Mountains also have a certain impact on atmospheric disturbances of the main part of the plain territories. First of all, the atmospheric precipitations in mountains many times exceed the correspondent amount of plain precipitations. Here the average annual precipitations amount to 500-700 mm.

The mountain territories being of exclusive importance in space-time distribution of water resources' distribution are the area for precipitation accumulation and glacier and eternal snow formation – the only sources of renewable resources of fresh waters. Meanwhile, the CA mountains are of great danger due to natural disasters: earthquakes, landslides, landslips, snow avalanches, mudflows, etc., which may significantly complicate the social and economic conditions not only of the population residing in the mountain areas, but also in all densely populated submontane and desert plains. Though mountains comprise less than 20% of the Central Asia territory, their ecosystems serve as a unique storage for variety of species of flora and fauna, and are the Guarantee for conservation and rehabilitation of landscape and biological variety.

High summer air temperatures in absolute values reaching +50°C are common for the climate of CA arid zone. The average July temperature fluctuates within +28°C in the north and +32°C in the south. The absolute temperature minimum reaches -40°C in the north and -26°C in the south.

The atmospheric precipitations amount to 100-200 mm. High summer-autumn temperatures and high air aridity cause soil drought and plant transpiration growth.

The vast CA plain part suffers from scarcity of fresh water. Coming from the high Pamirs-Altai and Tien Shan mountains, the largest rivers, the Amudaria and Syrdaria Rivers, flow along the sandy desert to the Aral Sea. To date, the stream of these rivers has been almost completely regulated and reaches the Aral in small volumes.

The underground waters, bedding in the submontane areas and along river arteries, are mostly used for water supply of cities and settlements and for irrigation of lands adjacent thereto.

Nearly 5600 lakes with the total area of 12 197 km^2 are located on the CA territory. The most famous lakes are the Issyk-Kul (Kyrgyzstan), the Karakul (Tajikistan), the Balkhash (Kazakhstan), etc. Those lakes are treated as closed depressions and are the giant vaporizers of river flow.

In crop production cotton is the primary crop, occupying the overwhelming part of irrigated territory of CA countries. Cereal crops, fruits, vegetables and melons and gourds are also cultivated here. The immense natural pasture territories allow developing a

Fig. 1. The CA physical-geographical map

less laborious but more profitable cattle-breeding branch – sheep and camel breeding.

About 159 mln ha of the total area in CA represent agricultural lands, with 82-97% of pastures, of which over 9 mln ha are irrigated lands.

The sub-region richest mineral, water and land resources promoted developing the industrial-agrarian sector. On the CA territory the tremendous resources of oil and gas, hydro-electric engineering, ferrous and nonferrous metals, coal, chrome, lead, uranium, etc. have been discovered and are being exploited.

The main areas of forest lands of CA countries are located in mountains. They play a significant role as a source for fuel, industrial wood, forest products and habitat of various flora and fauna species. A rich landscape variety specifies a great recreation value of mountainous areas as well as conditions for tourism development.

2. Main socio-economic tendencies of the regional development

After the collapse of the Soviet Union in 1991 the drastic economic recession, which had a negative impact on the living standards of the most part of the population in the region, has become one of the most serious consequences for the CA countries. Within the most pronounced social problems the following ones have appeared: high poverty level (Kyrgyzstan, Tajikistan) and sickness rate, unemployment, and reduction of life and birthrate expectancy.

Despite the CA countries geographically present a uniform and historically interrelated region, they are considered to be heterogeneous due to their situation and development.

Despite the differences in territories, number of the population, resource and economic potential, the CA countries are brought together due to some common complications: an access to the world markets, environmental problems, significant exposure of the territories to natural disaster and anthropogenic pressure, unsatisfactory system of social security and problems of public management aspects.

In 2003 the CA countries (except Turkmenistan) took lower positions against 1992 in the human development index (HDI): Kazakhstan – the 80th; Kyrgyzstan – the 111th; Tajikistan – the 122nd; Turkmenistan – the 97th; Uzbekistan – the 109th.

The drastic decline of production level and revenues resulted in GDP consolidated losses, which vary from approximately 20% in Uzbekistan up to 70% in Tajikistan during the period of 1990-1999, and approximately 40% in Kazakhstan, 45% in Kyrgyzstan and 50% in Turkmenistan. Since 1999 all the Central Asia economies have achieved relatively high production rates, that was stimulated by the combination of rehabilitation of production, reforms/high prices for minerals, and the positive growth in the neighboring countries, Russia and China in particular (7).

Macroeconomic stability gradually replaces a regular growth of inflation, budget deficit and debt liabilities. Though there is still a high external debt in some CA countries.

The countries of the region also differ in the level of attracted direct foreign investments. The biggest investments are assigned into the economy of Kazakhstan, followed by Turkmenistan, Kyrgyzstan, Tajikistan and Uzbekistan.

By 2003 all CA countries have achieved certain progress in the field of reforming state management of economy sectors.

Governments of the countries undertake actions to increase revenues of the population, carry out agricultural reforms, realize the program for employment and job creation, develop infrastructure of the village. Conditions for the rapid development of the small and average business are formed, Programs and Strategies to control poverty and unemployment are implemented (Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan).

The positive tendency of the CA countries to regional aspects of economic development, political stability and international integration has been reported.

3. Assessment of mountain lakes

The Middle Asia lakes have been studied for over one century, the beginning of which goes back to the second half of the 19th century, when extensive geographical researches of Turkistan's nature were undertaken.

Three periods are notable in research of lakes: pre-revolutionary (till 1917), pre-war (from 1921 till 1941) and modern (since 1950 till present) ones.

Within 1848-1849 the A.I. Butakov – headed expedition made an instrumental survey of the Aral Sea and the first map of this sea was published in 1850. According to V.L Schultz those researches are to be considered a start-point of hydrological researches on the territory of Middle Asia.

At the same time the first data on the hydrography Middle Asia lakes are given in the works of Arabic and Middle-Asian geographers of the Middle Ages, which are related to the X-XI centuries. They described and mapped the Aral (Hozerm) Sea, Sarykamysh lakes, the Issyk-Kul lake (Barskhan), Chatyr-Kyol (Kyuren-Kul), Song-Kyol. Abu-Raikhan-al-Biruni, Zakhriddin Babur and Muhammad Haidar Mirza were among the most prominent Middle-Asian geography scientists of the 11th-12th centuries.

Systematic study of the Middle Asia territory has begun in the second half of the 19th century. During that period an absolute contribution into the studying of the Middle-Asian lakes has been made by such prominent researchers of Turkistan as P.P. Semenov-Tyan-Shanskiy, A.P. Fedchenko, A.A. Severtsov, A.V. Kaulbars, A.A. Tillo, A.S. Berg, whose investigations are closely related to activities of the Russian Geographical Society founded in 1845.

Important or hydrographic researches of the Eastern Pamirs were held in 1877-1878 by the expedition headed by N.A. Severtsov – The Karakul, Rangkul, Shorkul and Yashilkul lakes and Sasykkul group of lakes have been described, a lot of lakes were mapped for the first time.

The Sarez Lake, which was formed due to the biggest landslip at the Murgab River valley in the Pamirs, has attracted scientists' attention since 1911.The researchers (G.I. Shpilko, I.P. Preobrazhenskiy, O.K. Lange, etc.), who visited and worked at that lake, made topographical surveys of the Usoysk logjam, geological observation of the lake banks and logjam, and identified the reservoir formation.

N.L Korzhenevskiy was the first to have summarized materials related to the hydrography of Middle Asian lakes in his work "Turkistan. Physical-geographical sketches", where he gave brief data on certain large lakes as well as a list of few small lakes located in the Middle Asia.

Table 1. Random Macroeconomic Indices

State	Annual growth OfGDP (%)	Inflation (%)	External debt against GDP, (%)	Net DPI against GDP, (%)	Net DPI (USD mln)
Kazakhstan	9,20	6,4	76,8	7,4	2 188
Kyrgyzstan	6,67	3,1	102,7	2,4	46
Tajikistan	10,20	14,4	64,7	2,1	32
Turkmenistan	16,90	5,6	30,2	3,5	218
Uzbekistan	4,40	10,2	48,1	0,7	70

Source: The World Bank, 2005

"The Middle Asia Lakes" work of LA. Molchanov, published in 1929, turned out to be the only reference manual on Middle Asian lakes till early 1960s. The work catalogued all known at that time lakes in the basins of the Amudarya, Syrdarya, Hi, Chu, Talas, Murgab, Tejen, Karakol, Aksu, Sarysu rivers, the Issyk-Kul Lake and Uzboy basins and the Caspian Sea coast. As a result 987 lakes with the total area of 94400 km^2 have been catalogued. The work also gives the brief schematic description of the lakes' regime and specifies the main provisions about location of lakes on the territory and their origin. In 1936 at the Tashkent branch of the SGI during the compilation of the Water Cadastre the new cataloging of lakes of Middle Asia has been made, as a result of which the amount and area of the lakes' mirror area was specified. 2400 lakes have been in total specified.

Organization of the stationary observation of hydro-meteorological regime goes back to the beginning of the 20th century. The lake regime study was limited with common seasonable hydro-meteorological surveys at the littoral and open zone, which have been held by expeditions.

The lakes have been and still remain to be badly studied so far from the point of view of stationary and systematic limnology researches. Suffice it to note that up to date there is no any purposeful lake station at the Middle Asian lakes, except the Aral Sea and Issyk-Kul.

Only by the end of the 1920-30s the posts started operating at lakes of the Syrdarya River valley, the lake network was extended at the Issyk-Kul Lake, stations opened at the Iskanderkul, Sarez and Yashilkul lakes with a small complex of lake surveys.

Currently, 20 posts are functioning, at which the observations of the level and ice-thermal regimes, water

Fig. 2. Map of Mountain Lakes of Tajikistan

chemical composition and a meteorological regime in the littoral zone of reservoirs are conducted.

The wide cartometry and bibliographic work was carried out in 1962-1966, while preparing a reference book "Surface water resources" to be published. It resulted in obtaining new data on the number and mirror areas of the lakes, their location on the Middle Asia territory and the literature used was annotated.

The issues of mountain lakes investigation turned out to be of primary importance in the middle of 1960s, which was almost completely discontinued in the beginning of 1940s. The basic tendencies in the study have become: assessment of potential breakthrough of dams of logjam and moraine lakes water resources of mountain lakes, obtaining of hydro-meteorological regime characteristics of reservoirs, which may serve as a model for mountain reservoirs under construction. Breakthroughs on the Issyk lake in 1963 and Yashinkul lake in 1966 caused a greater interest in the mountain lakes.

Data on morphometry and morphology of lake bowls and hydrological regime of more than 300 lakes was obtained as a result of investigations for revealing breakthrough-risky lakes carried out in 1966-1975, and a list of risky mountain lakes was determined, which require measures for preventing of their potential breakthrough.

35 lakes in South-West and Central Tajikistan were reconnoitered in 1962. The Main attention was paid at the study of water chemical composition and physical-chemical properties of lake bed sediments.

In 1963 the study of closed lakes of Eastern Pamirs continued. 13 reservoirs were surveyed; the chemical composition of water and bed sediments were studied, geological structure of lake basins was ascertained. The closed saline lake Sasykkul was exam-

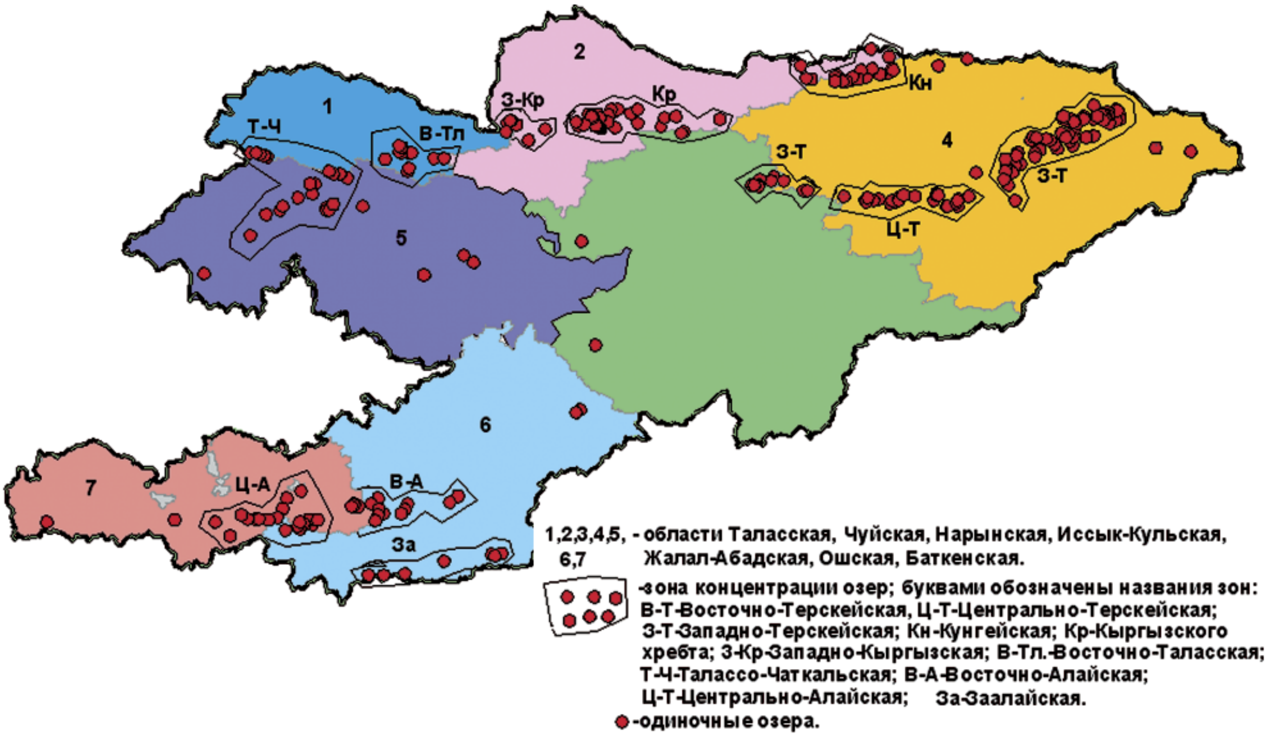

Fig. 3. Location diagram of concentration zones of breakthrough lakes at the territory of Kyrgyzstan.

ined, waters and underground brines of which are of industrial interest due to the content of boron, soda and rare elements, because of the cases of catastrophic breakthroughs of Central Asian mountain lakes, a Assembled Geological Expedition together with the VSEGINGEO Institute since 1967 has continued studying the lakes in Tajik SSR with the purpose of identifying their mudflow risk.

Researches for identification of stability of the Usoysk logjam (the Sarez Lake) have started since 1967. The whole lake basin has been studied with the purpose of determining degree of its mudflow risk. A package of topographic and geophysical works has been carried out and the Sarez Lake was concluded to be in real risk of breakthrough, requiring further researches.

The reconnaissance surveys of Marguzor, Iskanderkul, Iston, Kulikalon (Tajikabad), Kazakkul and Chashma-i-Sangak lakes was performed in 1968 in order to determine the risk of their breakthrough. Within the same period aerial survey of 94 Pamirs lakes have been made *[45]*. In 1987 "Lakes of Middle Asia" monograph by A.M. Nikitin was published, which summarized all data on the Middle Asian lakes *[23]*.

There are 1449 lakes in Tajikistan with the total area of 716 sq. km *[44]*, (different researchers present a different number of lakes depending on initial materials, which served as a basis to calculate lakes), comprising 0,5% of the republican territory. Nearly 80% of lakes and their major area are located in the mountainous regions of the Republic in the interval of altitudes of 3000 – 5000 m above sea level. The biggest lakes and their types are shown on mountain Lakes of Tajikistan map *(Fig. 2)*.

There are 1923 lakes with the total area of the mirror of over 0,1 km^2 within the territory of Kyrgyzstan, of them approximately 100 lakes have the area of more than 1 km^2. *Fig. 3* demonstrates a diagram of location of concentration zones of mountain lakes (groups of lakes) of breakthrough risk.

Only Sarez Lake, on the banks of which Irkht hydrometeorology station is located, has been thoroughly studied at the end of the last century. Detailed maps of the lake depth, water temperature and chemical composition at various depths have been made. Some small pre-glacial lakes being of breakthrough risk have been surveyed with the aerial technique.

The reconnaissance investigation of mountain lakes located along the Pamir path was carried out in summer 2005. It was stated that small lakes have become shallow and their area has shrinked. The branch between the Rangkul and Shorkul lakes turned into a narrow duct and a distance between those reservoirs has increased. The Sasykkul Lake has also decreased in size. None of significant changes have taken place at the Karakul Lake.

The assessment of CA lakes remains extremely unsatisfactory. There are no any information about such ad hoc lake researches as wave height, streams, transformations of alluviums, sediments and silting of lakes, reforming of banks, possibilities of formation of gravity deformation of slopes along the lake perimeter.

4. Mountain lakes as potential risk sources

Among dangerous natural processes developed on the CA territory the mudflows, which are formed during breakthroughs of mountain lakes, are noticeable for their specific catastrophic character. A lot of inhabited areas, highways, electric mains and pipelines, agricultural lands and pastures are involved into the zone of affection.

As it was stated above, over 5600 lakes are located on the CA territory, over half of them form mountain lakes. Concentration of a great number of lakes in the mountain areas is explained by climatic and morphologic-hydrographic peculiar features of them, as the CA mountains serve as moisture accumulators, forming the run-off of Central Asian rivers, as well as by favorable geomorphological and geotectonic conditions *[23]*. Complex investigations of mountain lakes for the issue of their breakthrough risk were carried out inadequately, in connection with which the information about the dam stability and possibility of their destruction and breakthrough is also insufficient.

The mountain lakes may be relatively divided into the breakthrough safe and breakthrough risky ones. The first ones prevail. 50-60% of lakes have got strong dams, the next 20-30% have been formed in the deep troughs in the area of ancient moraine development (like Arabel syrts) and are also stable. Only 20-30% against the total number of lakes do not have got strong dams, consisting either of moraine-glacial formations, or of loose-fragmental slightly connected deposits. Those dams may be damaged being impacted by various factors. In such cases lake breakthroughs occur, often being accompanied with catastrophic consequences for inhabitants of downstream valleys and plains.

It should be emphasized that a part of lakes in the process of their development and in the process of development of geological situation of their region may transfer from one group into another. Thus, great earthquakes may cause breakthroughs of lakes with the most stable dams. On the other hand, while moraine-glacial complex transfers into the moraine one (melting of buried ice), a moraine-glacial lake becomes a moraine one. Nevertheless, subdivision of mountain lakes into two groups is of great importance, both for their study and practical appliance.

As a result of investigation of lake dams and lake baths criteria are revealed, due to which typification of lakes is made and degree of their breakthrough risk is estimated. Based on lakes of breakthrough risk a breakthrough mechanism is to be identified and its model is to be designed, with the help of which amount of breakthrough flow discharge is calculated. Estimation of breakthrough flow discharge is a very important parameter of breakthrough lakes as the possibility of transformation of breakthrough flow to the mudflow and the area of mudflow damage depend on it.

As a rule, the mountain lakes belong to the remote geological threats (from the point of view of distance and not of time), as they are formed in mountainous areas, far from inhabited settlements. They are mostly located in mountains, in uninhabited areas. The mountain lakes contain certain water reserves, which may be of a great destructive force in certain conditions. Therefore, mountain lakes are to be referred to the most dangerous sources of natural disasters.

As researches of the latest decades showed, climate changes cause significant changes of environment and a tendency of snow-glacial cover reduction as well. The probability of wide development of new mountain lakes with dams formation due to a glacial factor is increased.

Moreover, the recently accelerated process of global warming causes the lake formation and the rise of a permafrost boundary. The latter process activates great amounts of loose detritus, which previously was cemented with ice. Big amounts of loose detritus have already been exposed to various gravity slope processes, which often show up as mudflows or other slower mass drifts. Landslips, stone glaciers and mudflows may create logjams in valleys and, thus, cofferdam river beds. Moreover, landslides may directly go down into the lake, causing formation of dangerous flood, which may catastrophically impact people, residing the river downstream. Though it is impossible to eliminate a physical reason of lots of natural events, the geological and hydrological surveys, the latest engineering and technological methods, awareness, readiness and efficient following of rules of land tenure and population settling may help reduce those risks.

Despite numerous attempts to study mountain lakes for their breakthrough risk and possible impact on the population and environment, there is currently no detailed list of glacial and breakthrough-risky lakes for the CA mountain countries. That is why it is of extreme importance to conduct an inventory and survey of glacial lakes in order to obtain data on the breakthrough-risky lakes, which may cause floods and mudflows and damage people at the river valley downstream.

The latest event related to the formation of mudflows, caused by a mountain lake breakthrough, took place in Tajikistan in 2002 at the Upper Dashtdara (the Shakhdara river basin). A breakthrough wave from the glacial lake caused a large-scope mudflow, with the total volume of 1.2 million m^3 of sediments, which partially destroyed the Dasht kishlak (village) and served as a reason for 24 deaths *(Photo 1)*.

The Sarez lake is considered to be another risk potential source in Tajikistan. A total damage caused by the Sarez Lake breakthrough is estimated at USD 5 billion. Territories of Tajikistan, Afghanistan, Uzbekistan and Turkmenistan will be subject to catastrophe while the breakthrough of the lake.

At present, over 200 lakes are at a risky stage in Kyrgyzstan. The most breakthrough-risky ones among them are lakes of types as follows: glacial (the Merzbahers Lake in the Central Tien-Shan), moraine-glacial (the Petrov Lake at the Upper Naryn River, lakes) and logjam (the Keltor and Minzhilki Lakes) ones.

672 cases of mudflows and floods took place during 1990-2005, including those caused by breakthroughs of mountain lakes. A scheduled and regular study of mountain breakthrough-risky lakes in Kyrgyzstan has started since 1966, following a catastrophic breakthrough of Yashynkul Lake in the Isfairamsay River basin, which took place on 18 June, 1966. The Cabinet of Ministers of Kyrgyz Republic issued a decree dated 15 August, 1966, which highlighted the necessity to survey mountain lakes of Kirgiziya in order to prevent a mudflow risk.

Photo 1. A cone of glacial mudflow removal at the Dasht kishlak.

5. Mountain lakes as potential sources for portable water supply, irrigation, recreation and mountain tourism

Issues of rational and multiple use and conservation of water of CA mountain lakes are of urgent importance.
The researches proved that water resources of average and small mountain lakes amount to 51,1 km^3. At the same time, 93% of water volumes are concentrated in the lakes as follows:

the Karakul (26.6 km^3),
Sarez (16.1 km^3),
Yashilkul (0.52 km^3),
Song-Kyol (2.8 km^3),
Chatyr-Kyol (0.61 km^3),
Karasu (0.22 km^3),
Sarychelek (0.49 km^3),
Iskanderkul (0.17 km^3) *[23]*.

The mountain lakes are potential sources of pure fresh and ultra-fresh waters. Meanwhile, their basic water resources are concentrated in one of the world biggest logjam lakes – the Sarez Lake with over 60% of water resources of fresh waters of the CA mountain lakes.

Utilization of the Sarez Lake water resources would allow to significantly increase assured water yield for irrigation in the Amudarya River basin, especially during extremely low-water periods, as well as to solve the Western Pamir energetic problem. Thus, the Sarez Lake might have become a natural reservoir of a multiple purpose.

Prospects for using mountain lakes as high-head power stations have not been completely studied. There are data that a possible capacity of diversion power station amounts to about 500 thous. kVt. However, the lack of powerful technical and material base and experience to construct of such stations does not yet allow implementing that proposal. Moreover, utilization of water of the Yashilkul mountain lake in the Western Pamirs as a hydro-regulating construction for “Pamirs-1” power station may serve as a good example of using mountain lakes in construction of power stations.

Basically, it is possible to install a mini power station at each mountain lake with the surface run-off. In Kyrgyzstan it has been already done only at the Akkul Lake (at the Kokemeren River basin). A power station as of about 5 kVt capacity for water supply of Akkul village has been installed here at the stream flowing out of the lake.

At present, the mountain lakes are first of all considered as risky objects. The lakes are studied insufficiently in other tenors and their utilization is too restricted.

The Petrova Lake (The Upper Naryn Rriver) of moraine-glacial origin is used in Kyrgyzstan as a source of water supply to provide portable and technical water to the Kumtor gold-mine. Other cases of utilization of waters of mountain lakes are not known.

In perspective it is possible to use mountain lakes for water supply of the inhabited areas and economic

Photo 2. Tourist center at the Iskanderkul Lake

entities. The logjam lakes are extremely perspective, as they are located at a small altitude and are more accessible against lakes of other category. Moreover, logjam lakes contain big volumes of good quality water. Even in 1871 while surveying the Turkistan territory, A.P. Fedchenko pointed out a real possibility to apply waters of the Iskanderkul lake for irrigating lands of the Zeravshan River valley.

Recently the interest in curative properties of some lakes and possibilities of their utilization for balneal purposes has been recently intensified. It is first of all water and lake mud of the Issykkul Lake and of small saline lakes such as Karakyol and Tuzkyol located along the banks thereof. The Samankyol lake at the Alabuga River basin attracts attention at the internal Tien-Shan. Water of the lake contains up to 2 grams of sodium and potassium per 1 liter against 6,6 gr/l of common mineralization. The water composition is characterized as hydrocarbonate-chloride-sodium one. The local population considers the Kutmankyol Lake at the Maylisai River basin as a sacred lake with medicinal water.

The mountain lakes are wider used as tourism and recreation objects. The recreation centers at the Issykkul, Iskanderkul, Shing and Kulikalon lakes are widely known. A lot of mountain lakes are included into the tourist routes as interesting objects.

6. Mountain lakes monitoring

The monitoring system and its implementation bodies are to be stated by the legislation of CA countries. First of all, they are state agencies established for the purpose of observation, assessment and forecasting environmental aspects and providing the population and organizations concerned with information required.

The existing in CA countries public system of monitoring and statistic information is characterized with the variety of sources, as well as methods of collecting and processing the data obtained.

The environmental status data are collected, summarized and distributed both by the central statistic agency and ministries and departments, assigned by the state to undertake responsibilities for the policy in that field.

MES monitors natural and man-caused emergency situations and natural disasters; the hydrometeorological agencies are entrusted with the monitoring of conditions of natural water resources and dynamics of their development.

Following the Soviet Union collapse, a system of monitoring and forecasting conditions of environment and dynamics of development of natural phenomena and regional objects has greatly reduced. Financing of the state specialized organizations in charge of environmental monitoring has been greatly dropped. Capacity building in the CA countries takes place depending on overcoming of economic difficulties.

Moreover, we have got as follows in the CA countries (especially in Kyrgyzstan and Tajikistan):

- imperfect institutional management structure in the issues of monitoring environment and some functions duplication;
- the priority tenors of objects and monitoring environment have not been properly stated;

- the lack of integrated methodology for assessment environment conditions (interrelation and interdependency with social-economic issues);
- the lack of necessary resources and low qualified staff potential in correspondent institutional departmental services, which exercise monitoring;
- insufficient use of GIS methods.

An important problem for CA countries is the issue of monitoring breakthrough risks in mountain lakes and early warning of the population. Resolving of this objective is an important factor for reducing natural disaster risks and preventing their consequences.

International organizations provide certain assistance in arranging a network of hydro-meteorological monitoring and studying of dynamics of natural processes.

For example, due to the implementation of international projects of WB, Aga-khan Fund, etc., the Ussoy dam at the Sarez Lake is now equipped with the latest early warning system and the system of monitoring its state, and the population residing along the river bed has the correspondent knowledge and skills and would be able to timely withstand any threat in case of breakthrough of the lake.

Thus, the improvement of the early warning system is an efficient measure to increase efficiency of natural disaster readiness and response, causing reduction of victims among the population and preventing social-economic losses.

The scientific technological infrastructure to conduct researches, surveys, analysis and mapping and, if possible, to forecast natural disasters and calamities related thereto has been established on the basis of the RT Informational-Analytical Center at the TR MES. The relevant information database is also being developed, the innovative scientific and technical methods to assess risks, monitoring and early warning are being approved, methods of space technologies, remote observation, forecast of climate and weather conditions, geographical information systems, modelling of disasters, risk and early warning assessment systems is being introduced *[8]*.

According to the character of breakthrough lakes location on the territory of Kyrgyzstan 10 zones of their concentration have been identified. Each zone lakes are combined into one group. Besides 10 lake concentration groups, there is a group of odd lakes, which are dispersed along the republic territory in 1 or 2-3 lakes. There are 22 lakes in the group of odd lakes. A diagram of location of concentration zones of breakthrough mountain lakes (group of lakes) is shown in *Fig. 3*.

Development of lakes at each of the concentration zones differs in its peculiarity. That is why a monitoring network is to cover lakes of various zones. The groups of each of the zones include lakes of various types: glacial moraine-glacial, moraine and log-jam ones. Of them the lakes of types representing each of the zones should be selected for the monitoring network. Moreover, it is necessary to take into consideration a stage of lake development. Lakes at the breakthrough-risk stage are to be regularly observed.

As far as mountain lakes are quite dynamic objects in their development, the monitoring network is to vary with their development. It should regularly be replenished with new lakes, and previously recorded lakes are to be recorded out after a breakthrough stage.

The methodology of conducting operating surveys at lakes in the processing of its monitoring as well as survey regularity are suggested to be determined in situ depending on a certain situation: i.e. a possibility of accesses and approaches to the lake, climatic and weather conditions, nature of lake development in each zone of their concentration.

Because of the lack of unified system of information presentation on mudflows and breakthrough lakes during carrying out monitoring in Republic of Uzbekistan, the GlavHydroMet Agency has worked out a program in two blocks "Mudflow Phenomena» and "Breakthrough Lakes". For the block "Breakthrough Lakes" the Section "Objects of National Economy Located in the High Mudflow Risk Zone, and Impact of Breakthrough Lakes on Them". The section gives basic reasons of the process development and parameters of manifestation, the nature of threat to the object and recommendations for preventive actions to avoid the danger of mudflow phenomena. The flood zone objects are also listed for the case of lake breakthrough; a flood waver "lag" time has been estimated. Moreover, the system "Hydro-meteorological Monitoring of Mountain Lakes" has been developed, which assesses the current state and tendencies of changing the basic parameters of hydrometeorological regime of the biggest breakthrough-risky reservoirs on the territory of Uzbekistan; priorities of development of the necessary surveys were determined and plans and programs were developed of the short-, mid- and long-term objectives for their realization. Options for equipping stations for survey, processing, transmission and analysis of hydro-meteorological data are proposed.

It would be probably advisable for the CA neighboring countries to study that experience in order to implement it in the region. It is also required to take into consideration a transboundary nature of the most breakthrough lakes, their location on the territory of one of the states and a possibility of damaging the neighboring countries. It is advisable to proceed to the solution of that objective with the beginning of rehabilitation of observation networks in the areas of flow formation.

7. Legal and institutional basis in the issues of studying mountain lakes

MES, which were founded in the CA countries for the development and implementation of a policy intended to prevent extraordinary situations, to protect human lives and to minimize damage caused, are in charge of reducing natural disaster risks. MES are to coordinate activities of various departments, regional and local administration bodies for working out and implementing action plans during extraordinary situations. MES are also entrusted with the function of training the local population and public servants to responding actions in case of extraordinary situations, to manage national reserve funds, material and technical resources, including foodstuff and medications.

The CA countries have achieved success of different degree in working out plans for training in extraordinary situations.

Currently, the policy in the sphere of extraordinary situations of CA countries contains a regional mechanism acting on the basis of collaboration of CIS countries within of the Intergovernmental Council for Extraordinary Situation during natural disasters or man-made catastrophes. The Council competence covers arranging collaboration treaties, working out and implementing of technical programs in the sphere of preventing catastrophes and mitigating their consequences, national system integration, as well as training and experience exchanging between relevant departments.

The adopted in 1998 by CA countries (except Turkmenistan) agreement on joint utilization of transboundary rivers, reservoirs and water infrastructure, establishes the basis for joint activities for minimizing of negative consequences caused by spring floods, landslips and other natural disasters. The Interstate Working Group for discussion of natural disasters of common regional nature has been established.

Insertion 1

In 2005 the CA countries (except Turkmenistan) joined the Hiog Declaration and Frame-work Action Program for 2005-2015, calling upon to decrease the risk of natural disasters and to develop international collaboration.

Insertion 2

Legislative basis in CA countries

Kyrgyzstan:

- *The Law "On protection of the population and territories against extraordinary situations of natural and man-made nature" (was adopted on 24 February, 2004).*
- *The "Procedure of identification of zones of flood and mudflow damage during mountain lake breakthrough on the territory of Kyrgyz Republic" (2001).*
- *MES of the Republic makes an annual regional forecast of the possible next year development of natural processes and includes mountain lake breakthroughs therein.*

Tajikistan:

- *The Law "On Civil Defense" (1995).*
- *The Law "On Protection of the Population and Territories against Extraordinary Situations of Natural and Man-made Nature" (2004).*
- *The Law "On Rescue Services and Status of Rescuers" (2003).*
- *The Law "On Fund for Elimination of Extraordinary Situation Consequence" (1993).*
- *Off-budget Fund for Elimination Consequences of Extraordinary Situations (1993).*
- *"Sarez" Agency was established at MES under the Decree of RT Government, which was entrusted with warning and training the population living in vulnerable areas in case of any threat related to the Sarez lake breakthrough (2002).*

Uzbekistan:

- *Statutory act "On classification of extraordinary situations of man-made, natural and ecologic nature" (1998).*
- *The Law "On protection of the population and territories against extraordinary situations of natural and man-made nature" (1999).*
- *Statutory act "On state system of warning and actions in extraordinary situations" (2001).*
- *Statutory act «Urgent measures for prevention and elimination of consequences related to missing floods and mudflows and landslips" (2003).*
- *Issues of insurance of the population against natural disasters are determined by legal acts of CA countries.*

8. Mountain lakes nature and factors causing their formation

8.1. Mountain lakes classification

The CA mountain lakes are presented with a wide variety of dimensions and contours. The mountain lakes' genesis depends on different interdependent factors of both endogenous and exogenous origin. For mountain areas the origin of lakes is mostly related to processes of newest tectonic movements and great seismicity, composition of mountain rocks forming lake dams, activity of landslip, rockslide and other slope processes. Climatic factors such as precipitation growth, moisture provision and thermal regime, and factors related to glaciation processes, snow-glacial cover dynamics, etc. are of importance in formation and development of the lakes.

There are a lot of mountain lakes classifications. Some researchers base classification on landscape features, the others – on genetic ones, while third ones apply combined approaches.

Classification by landscape attribute

a) Glacial lakes located on glacier or impounded by it, their depressions partially or completely consist of glacier body.
b) Moraine lakes located at the surface of present-day moraines (terminal, lateral and middle ones)
c) Mountain-valley lakes located in mountain valleys out of present-day glacial-moraine complexes. This group also includes lakes located at the ancient moraine.

Classification of lakes by genesis

(G.A. Kernosov [44])

Tectonic lakes, originating as a result of erogenic processes during the earth's crust drift (faults and shifts); they are noted for large dimensions and depths.

Logjam lakes originated as a result of fall of rock masses from mountain slopes into the river bed during landslips and landslides, mainly during seismic vibrations of the earth's crust. Such lakes are usually located at places with a deep erosive incut or steep valley slope.

Sunken lakes formed in the relief depression and lacking a strongly pronounced dam.

Glaciogenous lakes are obliged for their origin to activities of both current and ancient glaciation. In their part they may be divided into glacial, kar, zandre and moraine lakes. They occupy the most upper zones of the territory within 4000-4500 m above the sea level and are fed with melted snow and ice waters. They differ in significant water vibration amplitudes. A discharge occurs with water spillover through a natural dam or filtration through moraines.

Moraine lakes formed in cavities made by ancient moraine. The ancient moraine sediments are involved in the lake cup formation.

Dike lakes formed as a result of damming of a basic river bed or lateral inflow by a drifting glacier, relatively quickly moving present-day moraine, ancient lava streams or mudflow sediments.

Thermokarst lakes, pit of which was formed as a result of uneven ice melting on the surface and subsidences resulted from thermokarst development in the glacier or moraine body.

Zandre lakes formed following damming of waters trickling from under the glacier by present-day fluvial-glacial sediments.

Hydrogenous lakes – dip, water-accumulating and water-erosion lakes are to be referred to them. The dip lakes in their turn are represented with karst, suffosion and thermal-karst lakes. The later ones are formed at the permafrost areas through buried ice melting out. Such lakes are located within 3000-4500 m above the sea level.

If a lake has been formed due to several reasons, a combined name under genetic features is to be applied, e.g. drift-tectonic, etc.

As it is stated above, the mountain lake classifications are nearly equal. At the same time, the difficulty is in identification of the type of the dam of mountain lake. Moreover, a forecast accuracy for the lake development, whether it would be of breakthrough risk or not, depends on a right identification of the reason of the lake formation.

S.A. Yerohin and O.A. Podrezov in Kyrgyzstan worked out a classification on the principle of breakthrough risk of mountain lakes. According to the composition and structure of dams the mountain lakes are divided into the following types:

Non-breakthrough lakes: 1) tectonic; 2) moraine; 3) crossbar; 4) drifting ones..

Breakthrough lakes: 1) glacial; 2) moraine-glacial; 3) moraine; 4) drifting.

Within some types of breakthrough lakes there are subtypes differing from each other (within the type) in dam genesis, lake bath morphology, conditions of feeding and discharge:

1. Lakes of glacial type include: thermal-karst and dyked lakes, lakes of thawing and intra-glacial capacities.
2. Lakes of moraine-glacial type include: lakes of intra-moraine depressions and thermo-karst craters.
3. Lakes of drift type include: drift-landslip and drift-mudflow lakes.

Lakes of each type and subtype have their own specific features, which are very important to know in order to identify really breakthrough lakes of a general mass of lakes.

Table 2. Middle Asia lakes under A.M. Nikitin [23]

Group	Type	Subtype
Mountain lakes	–	–
Tectonic	Intermountain troughs, intermountain troughs, logjam platform sags	–
Glaciogenous	Glacial, kar, zandre, moraine	–
Gravity	Landslide-landslip, snow-avalanche	–
Hydrogenous	Dip, water-erosion-accumulative	Thermokarst, karst, suffusion delta, ox-bows, stretch-terminal, lagoonal
Deflational-shorous	–	–

Table 3. Lakes classification by dam types according to Zh. Schneider [40]

Lake type	Description
A	Lakes with glacial dams or lakes located on ice
B	Lakes dammed up with moraine (reservoirs formed in depressions left by old glacier tongues)
C	Lakes, which dams have been formed as a result of mass drifts (moraine dam or landslip material)
D	Big lakes with composite dams (moraine dam and landslip material)
E	Lakes on ledge rocks with dams of stable hydrological structure

Non-breakthrough lakes:

The tectonic lakes are referred to intermountain and intermontane troughs. There are three of them on the territory of Kyrgyzstan: Issyk-Kul, Sonkul, Chatyrkul. They have a great area and capacity. The first and third of them do not have any discharge, while the second is a running one.

The crossbar lakes. For this type of lakes the follows conditions are typical, which determine stability of their dams***:***

1. The dam is represented with a rocky crossbar. The crossbar is bare or partially covered with loose-clastic sediments.
2. There is a depression in the rocky crossbar ridge. This is the so-called cofferdam, through which the lake waters are to flow down. The waterway bed flowing out of the lake, is usually formed with rocks at the crossbar area.
3. Water discharge from a lake through the cofferdam happens in a stable regime. All the "surpluses" of the lake waters are discharged in that way. The cofferdam is a discharge threshold.

A facies analysis of sediments, which form lake dams and lake bath ledges, shows that they are mostly represented by ancient sub-complex facies: Late Holocene, Early Holocene, Upper Pleistocene moraines, Early Holocene colluvium and deluvium. A wide age range of sediments, which form lake dams and lake bath ledges, testifies to a quite long life period of crossbar lakes, amounting to several thousand years. The present fact proves that crossbar lakes are the stable natural formations.

Moraine lakes. The moraine lakes may also be "long-livers", where a surface run-off is developed as a glacial component of their dams melts, and they are transferred into the non-breakthrough lake group. A well-developed system of water in- and outflows stipulates for a long life (thousands of years) of moraine lakes. The moraine lakes formed in the intramoraine depressions currently are running, and have big capacities up to several millions of cubic meters (the Chokolyke Lake in the Upper Valleys of the Juuka River – 6.1 mln m^3, the Chonkurkel Lake in the Upper Valley of the Barskaun River – 4.4 mln m^3). There is no buried or moraine-inclusive ice in sediments, which form dams and lake bath ledges of moraine lakes. All those sediments are mostly represented by ice-containing (ice-segregation) moraines and frozen rocks of colluvial, dealluvial, prolluvial and alluvial-prol-luvial genesis. That dam composition secures stability thereof.

Logjam lakes are formed in the bottoms of mountain valleys, higher than powerful mudflow logjams. The lakes usually disappear after breakthroughing of such logjams. However, the cases, when lake bath is partially empted, might happen.

A surface run-off appears in the lake. It turns into a calm development phase and may exist for hundreds of years. The following lakes belong to them: the Kok-Moynoc lake in the basin of the Tuyuk-Issykat River, the Chon-Aksu-medium Lake in the Chon-Aksu River valley.

Breakthrough-risky lakes:

Glacial lakes. Baths of thermokarst glacial lakes are formed on the surface of present-day glaciers in thermokarst craters and depressions. The ledge glacier areas are most favorable to form thermokarst craters. The Jardy-Kai-eastern Lake on the northern slope of Kyrgyz ridge is typical for this case. Capacities of those lakes may amount to several tens of thousands of cubic meters.

Glacial lakes of impounded subtype have been formed as a result of impounding activity of glaciers. Regarding a wide-known Merzbaher Lake the glacier of the major valley of Yuzhnyi (Southern) Inylchek takes such effect in respect of the lateral valley of Severnyi (Northern) Inylchek. The Merzbaher Lake breakthroughs occur once per 2-3 years. In certain years that lake had twice breakthroughs. This happened in 1966.The Buzulgansu Lake also belongs to the breakthrough-risky ones.

During the aero-visual survey one more type of glacial lakes was observed, as ***lakes formed on the surface of glaciers during the process of their melting***. However, that type did not provoke a great interest, because, first of all, glacial dams of those lakes are dissected by a lot of cracks, along which melt waters come inside glaciers and flow down to their peripheries along inter-glacial passages, i.e. there are no conditions for accumulation of big amounts of water on the glacier surface; second, consumption of the breakthrough flows from such lakes depends on discharge capacity of intraglacial passages, and it is usually not high and does not exceed 10-20 mVsec. It results from the passage branching and their intensive tortuosity, thus increasing resistance forces to water movement and significantly decreasing discharge capacity of passages. Besides that crimps and a roof of intra-glacial passages consist of strong pure or moraine-containing ice. That is why, immediate dilution of passages is impossible *(Photo 3)*.

The ***intra-glacial lakes*** may be ascribed to breakthrough lakes, which are formed inside intra-glacial reservoirs. They are not visible from the surface and become apparent during their direct breakthrough. Such breakthroughs usually stipulate for the formation of powerful glacial mudflows. The intra-glacial reservoirs are formed not in each glacier but in places with icefalls with a complex branched system of intra-glacial passages.

Breakthroughs of intra-glacial reservoirs are quite a wide-spread phenomenon. They often contribute to the formation of powerful glacial mudflows. The most bright examples of such mudflows are those ones at the Aksay River valley (the Ala-Archa River basin, on the northern slope of Kirgiz Ridge), in the Angysay River valley (the Ton River basin on the northern slope of Terskay-Alatoo Ridge).

The moraine-glacial lakes are those formed on the surface of moraine-glacial complexes. The most breakthrough lakes of that type are formed in the bottoms of intra-moraine depressions; however, the lakes of thermokarst craters have lately attracted attention after the Shakhimardan tragedy of 1998.

The intra-moraine depression lakes. The lake baths of that subtype are formed in the internal moraine depressions after a glacier recession. The bottom and boards of depression are composed of waterproof rocks, represented by the following kinds:

1) pure ice;
2) moraine-bearing ice;
3) ice-bearing moraine;
4) frozen loose-detrital rocks.

Conditions of melting water outflow from depression through such waterproof screen are quite complicated. That is why water is accumulated in bottoms of intramoraine depressions. It is warmed in the sun up to 8°C – 10°C. The ice and ice-bearing rocks in the bottom and boards of depression are melted due to its heat. The lake bath is formed. A water capacity in such baths may reach over 1 mln.m^3. For example, the Chetyndy Lake with the capacity of 1400 thous m^3; the Petrov Lake with the capacity of 50 mln.m^3 *(Photo 4)*.

Depending on the ratio of melt water inflow into the intra-moraine depression and it outflow a lake bath may cover either a part of depression or almost its complete bottom.

The lake bath development depends on two factors: 1) thermal-karst activity of melt waters; 2) composition and structure of moraine-glacial formations, which form the bath bottom and boards.

There are three types of bath lakes: 1 – formed directly at glacier tongues, 2 – with retreating from them glacier and 3 – occasionally impounded with water. The first ones develop in all directions, predominating in the direction of retreating glacier; the second ones have already accomplished the active phase of their development and are in a quiet phase, and only the third ones are breakthrough risky. A mechanism of plugging of the canal run-off is considered as the most difficult to explain and to forecast the breakthrough process of those lakes. It has been insufficiently studied yet.

The ***thermo-karst crater lakes*** are a unique subtype of moraine-glacial lakes. The thermo-karst craters are mostly formed on the bank ridges of terminal moraine, slateral and front moraines, and on the surface of terminal-moraine tongues. They are often related to the areas of extension and deepening of the intra-moraine canals of the run-off. Their number at the large terminal-moraine complexes may reach several dozens.

The thermo-karst craters appear in the area of buried ice melting. Their formation mechanism has been poorly studied yet. They are probably resulted from the action of thermokarst processes in the recurring veins or fractured ices. Crater water accumulates due to the ice melting forming crater bottoms and boards, thawing of snow dropping into craters. The melt water run-off from moraine swell slopes, surrounding a crater, is also possible. The area of basin for feeding craters is quite small and usually comprises 0.01-0.1 km^2. However, due to run-off obstruction the big amount of water amounting to several tens of thousand cubic meters may be accumulated in craters. The water run-off from craters is underground, and water is accumulated only in locations, where it is obstructed. That is why lakes in thermo-karst craters may be said to be formed not due to the large water inflow, but due to the run-off obstruction. The risk of breakthrough of such lakes poorly studied till nowadays, but the Shakhimardan tragedy of 1998 proved that breakthroughs of such lakes may be quite dangerous. Throwing through of the run-off underground canals and their opening may occur under certain conditions. In that case the lake is broken through and discharge of the breakthrough flow may reach several dozens of cubic meters per second. The young thermo-karst craters are considered to be the most breakthrough risky, as they are actively developing due to the thawing throough of buried and moraine-bearing ice.

The moraine lakes. The moraine type lakes are located below the moraine-glacial ones from the hypsometric point of view. Dams of such lakes are represented with ancient moraine complexes of frozen loose-fractioned slightly permeable rocks. Their baths have been inherited from moraine-glacial lakes of the early holocene and pleistocene age. In the process of moraine-glacial lakes transformation into the moraine ones, a risk of breakthrough of the former ones converts to the latter ones, though its degree significantly decreases. A surface run-off is mostly typical for moraine lakes, that is why they have been traditionally considered as non-breakthrough risky ones. However, during studying moraine lakes it was found out that some of them may become breakthrough risky in any certain situation.

Logjam lakes. The logjam-type lake formation is related to earthquakes and mudflows *(Photo 5)*. In first case the logjam-landslip subtype of the lake is formed and in the second one – the logjam-mudflow subtype of the lake is formed.

Logjam-landslip lakes. Following enormous landslips of mountain slopes caused by seismic tremors, strong logjam dams are formed in the valley bottoms, above which significant water capacities are accumulated amounting to from several hundreds of thousands to hundreds of millions of cubic meters. For example, the Koltor Lake (2.5 mln m^3) the Sarychelek Lake (515 mln m^3).

A run-off from the logjam-landslip lakes occurs both by the surface and by underground ways. Within the lake development process the underground run-off is replaced by the surface one. The transformation of one type of run-off into another is usually accompanied with catastrophic breakthroughs of lakes (the Yashinkul Lake in 1966), that is why the lakes with underground run-off are considered to be breakthrough risky among the logjam-landslip lakes. The biggest among them are: Sarychelek Lake (515 mln m^3)), Kulun-big Lake of 118 mln m^3, Kara-Su Lake of 223 mln m^3, Kara-Toko Lake of 49 mln m^3. The surface run-off at some of logjam-landslip lakes appears only when lake baths have the maximum impoundment (the Koltor Lake).

The logjam-landslip lake breakthroughs occur on the surface through erosive closure channels. Meanwhile, consumption in waterways reaches from several hundreds up to the first thousands cubic meters. Compared with the moraine-glacial lakes, the logjam-landslip lakes break through more seldom; however, their breakthroughs are more destructive.

Logjam-mud flow lakes are formed in the mountain valley bottoms, over the powerful logjams formed by mudflow carryovers during their outlet from their lateral tribytary valleys. Within a short period of time (from several hours up to several days) the lake bath is overfilled and a surface overtopping via a cofferdam and its erosive wash-out start. A closure channel is formed in the dam body, through which the complete or partial discharge takes place. The breakthrough flow discharge reaches at that time several hundreds cubic meters.

8.2 Climatic factors of mountain lakes formation

Temperature regime

Changes in one part of climate system may cause consequences, which with time are characterized with a tendency for intensification. For example, a snow cover reduction due to the temperature increase may decrease the sun energy reflection back to the atmosphere that, in its turn, will cause the increase of energy volume absorbed by the land surface. It would cause temperature increase, and, thus, more dynamic ice melting. But cloudiness intensification possibly caused by more intensive melting may decrease, for example, intensity of sun radiation reaching the Earth surface, and, finally, will decrease surface temperature.

The climate global change caused by "the greenhouse effect" currently turned out to be also the most important political problem. Climate changes would practically cover all spheres of human activities.

In December 1988 the UN General Assembly already adopted the Resolution on "Conservation of global climate for current and future generations of the mankind", which emphasizes that the problem of climate changes is to be globally settled.

Results of numerous estimations made with the help of climate models are the evidence of the global increase of air temperature within the range of 1° - 3.5° by 2050 that may negatively impact socio-economic development of many countries. Tajikistan located in the arid zone and in complicated physico-geographical conditions, where almost all climatic zones are present, is considered to be vulnerable to negative consequences of climate changes.

The monthly release data have served as basic information for assessment of changes in the statistical arrays of the air temperature and precipitations *[44]*. The missed observation data on the air temperature and precipitations have been restored for a number of stations. The restoration method is based on diversified linear regression, applying synchronous data as predictors. According to the precipitations the data on separate stations have been restored because of low space-time correlation links caused by the great variability in precipitations on the territory.

During the period of 1940 up to 2000 the value of changes in the average air temperature in Tajikistan valleys is positive and the trend varied from 0.3° (Hudjand) up to 1.2° (Dangara).

A tendency of temperature changing in mountain areas is ambiguous: it is negative in Khushyeri, Rashta and Sagiston areas (-0.8°; -0.3°), but is positive on the other territories, mostly amounting to 0.4°-0.5°, and -0.8° only in Phaizabad and Ishkashime.

The annual temperature growth by 0.2°-0.4° is observed in high-mountain areas (over 2500 m over the sea level) and the temperature decrease (-1.1°) is recorded only in the high-mountain crater of the Bulunkul Lake.

The temperature diagrams show that the annual average air temperature in 1940-1960 is negative. The trend has changed since 1960 and become positive. The situation specified makes it possible to talk about the stable climate warming since 1960s of the 20th century, not only the size of trends but also their direction having been changed if compared with the previous period. The tendency for warming still persists.

Researches of climatic factor impact on mountain lake formation and development in Kyrgyzstan demonstrated that by the end of the 20th century the annual average air temperature has significantly increased because of the global climate warming, but amounts of precipitations have not really changed.

Based on data of 5 meteorological stations (MS) of the South-West Kyrgyzstan (SWK) and Internal Tien-Shan (ITS), located in the range of 1.5-3.6 km, high, the estimated coefficients for linear trends of the average air temperature and precipitation totals are given for 1930-2000 *(Table 4.)*

Apparently, on the average in Kyrgyzstan the average annual temperature has increased by 1.6°C (January by 2.6°C, July by 1.2°C) in conversion for 100 years, and precipitation amounts have not really changed both per year and per seasons. At that, in SWK the average annual temperatures have slightly increased (Pacha-Ata at 0.6°C), whereas in high-mountains the increase was much more significant (Sary-Tash at 2.4°C). The annual precipitation amounts in both areas have increased: considerably in the middle-mountain area, by 239 mm, and less in high-mountain area by 61 mm. It respectively comprises 32% and 16% against the norm.

According to the data of 3 stations, in IT'S the average annual temperatures in conversion for 100 years have increased by 1.2°C, at the same time, an increase range comprised 1.1°C...,5.2°C in January, and 0.5°C...,1.9°C in July. The annual precipitation amounts either have not really changed (Naryn, 11 mm increase per year) or have greatly decreased by 126 mm and 167mm, comprising 41%-47% against the norm.

Thus, in accordance with the data of instrumental observations for the territory of Kyrgyzstan, in the last century the climate warming took place, much higher than that the global one for the whole Earth (0.6°±0.2°), with the change of growth in the middle-mountain and high-mountain areas in the range of 0.6°C-2.4°C and with quite nonhomogeneous changes of precipitations along the territory – from 16%-32% increase till 41%-47% decrease.

Based on the global climate models (GCM) the Kyrgyzstan future climate scenarios have been estimated for the middle-end of the 21st century. TOC warming values and R precipitation ratios obtained in accordance with one of the basic models are given in *Tables 5 & 6*.

At the same time, two scenarios of greenhouse gas emissions were used: IS92a for mid-high emissions with CO_2 concentration duplication by 2100, and IS92. for mid-low emissions with 35% concentration growth.

As it could be seen, for scenario IS92a the average annual temperature will increase by 3.0°C by 2100 and for scenario IS92c – by 2.4°C. By the 21st century the two scenarios growth will comprise 1.4°C. At the same time, precipitations will significantly increase – by 54% and 16% by the end of the century for IS92a and IS92c, respectively. By the middle of the century the precipitations will increase by 37% and 18%.

All the facts certify that warming, which began at the end of the 20th century, will most likely keep its tendency during the whole century and will be possibly accompanied with great precipitation increase. Really, conclusions on precipitations should be more careful, as changes actually observed in the 20th century and scenarios for the current century give a great heterogeneity of precipitation field along the territory and high-altitude zones.

Based on the stated above, the growth of breakthrough-risk of should be anticipated. Such a forecast is first of all stipulated by the growth of ice and snow melting due to both just temperature factor and radiation conditions that will break the balance in the 'tlimate-lake"system with a possible thawing of permafrost, damage of moraine dams and big additional amounts of downpour water inflows to the lakes. In these conditions an urgent necessity appears to thoroughly study the possible regional climate fluctua-

Table 4. Values of the temperature linear trend (β_T°C./10 years) and precipitation (βr mm/10 years) in the 20th century

Region	Meteorological station	Z, км	β_T ⁰C/10 years			β_r mm/10 years		
			year	Jan.	July	year	Jan.	July
SWK	Pacha-Ata	1,54	0,06	0,29	-0,01	23,9	1,6	3,6
	Sary-Tash	3,16	0,24	0,37	0,17	6,1	1,0	-0,5
ITS	Naryn	2,04	0,12	0,52	0,05	1,1	-4,8	-0,1
	Suusamyr	2,06	0,12	0,05	0,19	-16,7	-0,6	-1,4
	Tien-Shan	3,63	0,12	0,11	0,12	-12,6	-0,2	-4,4
Kyrgyzstan		0,16	0,26	0,12	2,3	-0,1	-0,4	

tions and their impact on the development of breakthrough risky lakes.

Moisture supply

The precipitations as well as air temperature are to be referred to one of the most important meteorological values, being a basic source to moisten land. A number of precipitations is to be mostly determined by orographic conditions and cyclonic activities.

Analysis of changes in the annual amounts of precipitation has revealed their significant fluctuation in time and space, and some very dry and very moist periods have been identified.

The decade of 1941 - 1950 was the driest one for all altitudinal levels, and a moist period was observed till 1960. Afterwards, certain positive and negative annual abnormalities alternated each other till 1990, then precipitation amounts went on increasing. A peak of positive abnormalities occurred in 1999, followed by a period wit h abnormally low precipitations.

The annual precipitation fluctuations are mostly caused by changes in atmosphere general circulation and may be significant. 1971 is considered to be extremely dry with a precipitation deficit as of 40% on the whole territory of Kyrgyzstan.

1969 turned out to be uncommonly damp for regions located up to 2500 m above sea level, when precipitations exceeded the norm over 60%. The heaviest precipitations occurred the upper in mountains in 1953 (150% against the norm), though 1969 was also abnormal for the given area, as the precipitations exceeded the norm by 40%.

There is somewhat different situation in precipitation trends. A trend for precipitation decrease was mostly observed till 1990s of the 20th century, and within the latest 15 years the trend for precipitation increase for the most part of the territory has been observed.

The climate data represents one of the most important information while strategic planning of nature management and environmental protection. Any changes in one part of the climate system may result in consequences, which are characterized with intensification tendency in due course. Though for the time being climate fluctuations are mostly of natural character, that change may be broken by human activities and the anthropogenic prevalence may occur within climate change conditions.

Nature of Mountain Lake Run-off

Water run-off in mountain lakes occurs in three forms as follows:

1) a surface one – by water overtopping through a cofferdam ridge (a cofferdam ridge is the dam lowest part in the lake regarding a water surface) while water level raises over that ridge in the lake;

Table 5. Warming scenarios (ΔT, °C) per year and by seasons according to the HadCM-2 model.

Scenario of emissions	Seasons 2050					Seasons 2100				
	Winter	Spring	Summ.	Autum.	Year	Winter	Spring	Summ.	Autum.	Year
IS92a	1,5	1,3	1,4	1,5	1,4	3,2	2,6	3,1	3,2	3,0
IS92c	1,5	1,2	1,5	1,5	1,4	2,4	1,8	2,6	2,6	2,4

Table 6. Precipitation changes' scenario (R) per year and seasons under HadCM-2 model.

Scenario of emissions	Seasons 2050					Seasons 2100				
	Winter	Spring	Summ.	Autum.	Year	Winter	Spring	Summ.	Autum.	Year
IS92a	1,26	1,17	1,64	1,41	1,37	1,46	1,22	1,84	1,64	1,54
IS92c	1,15	1,09	1,25	1,23	1,18	1,26	1,09	1,06	1,24	1,16

2) an underground one – by filtration and jet stream through intra-glacial, intra-moraine and underground run-off ducts;
3) a combined one – by simultaneous surface and underground run-off.

Lakes of each genetic type have got all the above-listed run-off forms. The underground run-off form proves an earlier stage of the lake regarding development of glacial (besides intra-glacial), moraine-glacial and logjam lakes. Lakes of those types usually have got a surface run-off in the final stage of lake development. The lakes of thermo-karst moraine-glacial subtype, which turn into moraine lakes of closed (cutoff) depressions (similar to the Chaish-low lake on the northern slope of Kyrgyz mountain ridge), serve as an exception as far as they become older.

Dependence of Mountain Lake Feed and Run-off on Hydro-meteorological Conditions

Water accumulation in the lake depends on hydro-meteorological conditions formed in the lake feed basin. Those conditions are to be identified with several factors as follows:

- air and water temperature in the lake within the period of lake bath filling;
- precipitation amounts in the lake feed basin;
- status of zero izotherm within a hot period of the year;
- ablation value of glacier and snowfield.

The role of each of above-listed factors in feeding lakes of various types has not yet been clarified, as far as expensive regime observations are required for this. That is why it is necessary to limit assessment of each of the factors importance in lake feeding to the qualitative and rarely to quantitative criteria.

Air and water temperature impact. Air temperature growth causes increasing glacier and snowfield thawing being the reason for water production in the moraine-glacial lakes and water level increase therein.

There is quite different situation with the logjam lakes. Water level therein almost has not got any daily variations. The level rise or fall occur within several days, proving its dependence not of average daily water and air temperatures, but likely of penta-logic or average ten-day temperatures.

Precipitation amounts in the lake feeding basin. Water production to the lake depends on precipitation. However, that dependence occurs in a complicated form. Showers at only some logjam lakes cause their direct level rise. Temporary acting flows are of great importance in feeding of such lakes. More often precipitation is accompanied with air temperature decrease causing water level recession in the lake. It is obvious in glacial, moraine-glacial, moraine and crossbar lakes.

In winter season mountain lakes are located under the ice, and precipitation will impact the lake water production only in spring-summer period following the yearly snow reserve thawing.

Status of zero isotherms within a hot period. The amount of melt water run-off depends on a zero izotherm status. The higher a zero izotherm level is, the more glaciers and frozen rocks would be covered with thawing, the bigger will be consumption of melt water flow, the bigger will be water production in the lake. Zero isotherm is closely connected with the impoundment of glacial and moraine-glacial lakes, and thus with the breakthrough risk thereof. The breakthrough analysis of glacial and moraine-glacial lakes during the last 50 years demonstrates that the lakes' breakthrough risk significantly rises while a zero isotherm develops up to 4500-5000.

Ablation value for glaciers and snowfields. Observations of water level changes in mountain lakes showed that in cloudy days, when the sun is closed with clouds, the lakes' level falls. It is mostly obvious on glacial and moraine-glacial lakes, and less obvious on moraine, crossbar and logjam lakes. The fall of the level occurs due to decrease of water production in the lake, caused by reduction of ice and snowfield thawing.

8.3. Impact of Geodynamic Processes on Formation and Development of Mountain Lakes

Geodynamic processes are of bigger intensity in mountainous regions, where the great partitioning of relief and high seismic activity contribute to the formation of gravity deformities on slopes. Formation of the Sarez lake due to the earthquake of 1911 is the brightest example for geodynamic forces to impact natural environment. The risk of this lake breakthrough has been threatening the Bartang River valley within 95 years. Until now nobody can tell with certainty whether the dam is stable or not, whether the Sarez lake will drain in natural way or water discharge therefrom will be catastrophic and will cause overwhelming victims (17 000 persons reside only in the Bartang river valley).

The slope gravity deformities (mudslides, landslips, etc.) under certain conditions may form secondary dammings in places of already broken through dams or in case of the dam broken through by water flows form a dam for the second time. Moreover, if there are gravity deformities of slopes along the lake perimeter, there may occur the situation of overtopping through the dam with a partial or full damage thereof and formation of enormous flood (such scenario is most likely while severe earthquakes). That is why it is of great importance to study mountain slopes along the lake perimeters. Unfortunately, this issue is not considered while studying mountain lakes. At best recommendations are given to thoroughly study sides of this or that lake. On the other hand, sometimes a lot of ungrounded slope gravity deformations, which are not such in fact, are revealed along the lake perimeter. For example, while observing the Sarez lakesides, some researchers referred stony glaciers and moraine strata on the lakesides to mudslides, which may cause wave formation and water overtopping through the dam with its further damage, if they fall down into the lake. With such approach actually all the mountain lakes maybe referred to the breakthrough risky ones. That is why it is required to apply a complex approach attracting a wide scope of experts to study slope gravity deformations.

In general, in extreme situations (severe earthquakes, abnormal intensive precipitations, temperature sharp rise) almost all mountain lakes (except glacial-depression ones) are of breakthrough risk, therefore it is necessary to determine zones of damage by catastrophic flood in all densely inhabited mountain valleys, where there are mountain lakes in their upper course and to take actions minimizing the risk of its impact.

8.4. Impact of glaciation on mountain lakes formation and development

It has been lately ascertained that in CA mountains in late Pleistocene (QIII) a mountainous-valley half-coated glaciation was formed with its glaciation centers, where from valley glaciers moved forward *[14]*. The glaciers' capacity reached at that time 2.5 km. Such amount of stone-bearing ice made a great impact on the mountain valley slopes, transforming the V-shaped valleys into the trough, or U-shaped. In the place, where there was the glacier body, steep smooth slopes have been formed with a moraine soft cover in favorable places bespreading those slopes as a raincoat. The glacier usually had got a head dyke in front thereof, containing a chaotic conglomeration of various size fractions, sometimes with rocky rejectors of enormous dimensions (up to 20-50 m in diameter). While a glacier degradation that head swell was kept intact at place, forming dykes on the valley bottoms. For example, there are up to 6 of such head dykes in the Pamirs valleys. Ridges formed by those sediments, are of 100-150 m high, with up to 5-6 km long (the Muksu River valley in its mouth part). The ridges are dissymetric. Sometimes they form a series of similar ridges divided by shallow gullies declining inside a tongue part (for example, the mouth part of the Shitharv River valley in the Pyandj River valley). Lots of researchers recognize such dykes as landslip formations, sometimes finiging difficulty in determining where a landslip occurred, and they give the names of two ridges at once (for example, the Marguzor Lake *(Photo 6)*. Often lakes were formed in frontal tongue part of the glacier (tsunga basin), which existed within various periods, depending on dyke structure (availability of buried ice, debris composition and their dimensions, and amount of melkozem filler). When a dyke is washed out, if a wash-out took place at the slope foot, on favorable conditions the rock mass gravity displacements occur (we'll call them as collapses, as a uniform generally recognized classification, being understandable for all specialists, does not exist), which again covered the valley and formed the lake one more time (theYashirkul, Zardevand Rivvakul lakes are to be referred to that type) *(Photos 7, 8)*. The wash-out of moraine dyke till a certain limit occurred in some lakes, and then stopped due to the availability of enormous lumps of original rocks or mountain rock prominence in the wash-out location. In that case the lake was kept but less in size (for example, the Oykul and Drumkul lakes in the Shakhdar River basin). In most cases a run-off from such lakes occurs as a filtration through a dyke.

As far as a glaciation is of pulsation nature, periodical pulsations or outbursts of glacier formation occurred against the general degradation background, which caused glacier attack, but in less dimensions. Each of such pulsations was followed by formation of terminal moraine dykes in river valleys or extended blade tongues in wide valleys of main rivers. The terminal moraine dykes coming out from lateral inflows into the main valley formed cofferdams in narrow river valleys, forming huge lakes behind them (for example, the Kudarin glacier blocked the Murgab River), which later broke through, as terminal moraines contained much ice causing catastrophic floods. In valleys of the main Pamirs' rivers the traces of such lakes survived as lacustrine benches. In the center of blade tongues in wide valleys the lakes developed, which survived till nowadays (the Karadara Lake at Khargush pass, the Chakankul and Kukjigit lakes).

Formation and degradation of such thick ice cover within a relatively short period (30-35 thousand years) resulted in damaging of isostatic balance and caused drastic increase of seismic tremors. Increase of seismic activity after a relatively fast ice thawing, a great fragmentation of rocks and significant reduction of ice cover, acting as a filler of river valleys, resulted in drastic activation of gravity displacement on slopes. Valleys are more peened with gravity blocks and become narrower and more meandering. Then thick strata of dammed, mudflow and landslip sediments are formed creating numerous lakes in the river valleys, which dams are later washed out and destroyed. Some rivers, which have earlier changed their beds, returned to their deserted locations, and some of them continue flowing in new canyon-like valleys (for example the Bartang River after junction of the Murgab and Kudara rivers). As a result, inadequacy of appearance of river valleys and capacity of loose sediments in their bottoms occurs *(Photo 9)*. When glaciers retreated, lakes were formed, some of which disappeared and the other exist till nowadays. The same situation occurs, when present-day glaciers shrink, i.e. new mountain lakes develop, dams of which consist of ice-bearing sediments. Such dams are quite unstable, easily washed-out and become potential sources of glacier mudflows.

8.5. Types of mountain lake dams

It is difficult to define a dam category as most researchers classify them taking their outward appearance into consideration, and do not really study internal structure of rocks comprising the dams. That is why various interpretations defining a dam type are available.

Based on geo-morphological researches made in Tajikistan and the Pamirs glaciation *[14]* it is suggested to distinguish the following main dam types, behind which mountain lakes are formed:

1. ***Tectonic dam type.*** This type is quite uncommon, as it requires availability of specific geological conditions: availability of troughs or grooves, and steep tectonic bench. The Karakul Lake in the Eastern Pamirs is considered to be the brightest example of tectonic origin lake in Tajikistan *(Photo 13)*.

2. ***Logjam dam type.*** It is formed by overlapping a river bed with slope gravity deformations: landslips, mudslides and rock failures. The Sarez Lake *(Photo 14)* and the Iskanderkul Lake *(Photo 15)* are the brightest representatives of this type of the lakes in Tajikistan.

N. R. Ischuk

Stone glaciers in Tajikistan

The stone glaciers are a unique form of cryogen processes manifestation in mountains. They may be of mountainous-valley (Photo 10) and mountainside types (Photo. 11).

The mountainous-valley type is the congregation of fractures, creeping out from circuses or kars in a form of long tongues (up to 3km). They are to be referred to the variety of relief frozen-glacial forms. One of the outermost items of the variety is a glacier buried under rocky fractures, the other one is a landslip and screes coarse fractional material cemented by infiltration ice. It has got well-defined current textures on the surface and, as a rule, a steep tongue end (up to 350-450). A genesis is not distinct. The author refers them to the glacial type.

The mountainside stone glaciers appear at steep cracked rocky slopes and sometimes, merging one into another, form quite extended aprons (up to 1 - 2km). Their structure is similar to the mountainous-valley stone glaciers; they may form long tongues, creeping out to shallow gullies and breakthroughs.

In most cases the stone glaciers represent complicated formations consisting of several stone glaciers ("stairs") following one another or laid on one another, sometimes comprising 6-7 and even larger generations. From the front and from sides the stone glaciers are limited with steep benches (the angle of natural side slope and even steeper) of a relative height from the first meters up to 40-50 m.

The stone glacier surfaces are covered with coarse fractional materials, sometimes up to several meters in diameter, in relic glaciers covered with melkozem.

Creeping out from confluent valleys of main valleys or from kar niches, they can block a river bed and form lakes (Photo 12). The stone glaciers may also creep into the existing lake and divide it into two parts. Stability of dams formed by stone glaciers depends on share of ice in them: the more there is ice, the less stable is the dam.

3. ***Composite dams.*** They are formed with combination of two types of damming: moraine sediments (they are mostly moraine terminal ridges with head dykes) and slope gravity deformations. Firstly, as a rule, a moraine damming is formed, which may be then washed out, and the lake is fully or partially discharged (for example, the Yashilkul Lake). If a mountainside is washed away, when the lake is discharged, the mountainside gravity deformation occurs and a secondary damming is formed, behind which the lake is again formed (the Zardev Lake in the Shakhdara River basin *(Photo 16)*.

4. ***Moraine dams.*** Their formation is caused by a moraine relief formation, i.e. a combination of moraine dykes, ridges and landslips. It is the most numerous dam type. It is spread everywhere above 2500 m, where moraine sediments are common. The Drumkul *(Photo 17)*, Kulikalon *(Photo 18)*, Marguzor *(Photo, 19)* and Nofin Lakes may serve as examples of such lakes in Tajikistan. Many researchers refer the majority lakes of this type, formed with glacier terminal ridges after their degradation, to the logjam group that is a serious mistake as it does not allow to correctly assess their development and dam stability.

5. ***Dams formed by stone glaciers or mudflows movements.*** They are formed during protrusion of stone glaciers or mudflows from the lateral confluents into the main valleys (for example, the Harkul Lake in the Shakhdara River basin *(Photo 20)*. Dams formed with stone glaciers (for example, the

Havrazdara Lake in the Tanymas River basin) *(Photo 21)* are mostly spread in Tajikistan mountains.

Besides the lakes formed by the mentioned above dam types, there are two more lake types (damless ones) related to glacier activities:

1. Thermo-karst lakes. They are formed on the glacier body or in the depth of moraine sediment if buried ice is available therein. They don't have any well-marked dams. They mostly form lake oval isometric forms and are characterized with small dimensions *(Photo 22 & 23)*. This is the most numerous group in locations of present-day glaciers.

2. Glacial-depression lakes. They are formed at plateaus, where glacial covers were formed in the glacial period, (the so-called glaciation centers) or in the bottoms of vast valleys. The Rangkul and Shorkul, Turumtaikul (Photo 24), Zaroshkul and Sassykkul lakes are considered to be the biggest lakes of that group on the territory of Tajikistan. Pulsating glaciers is another reason for mountain lakes formation, at which insufficient attention is paid. There were 29 pulsating glaciers on the territory of Tajikistan as of the end of 1980. They periodically become active and start moving, protruding to main valleys and forming dykes, which are easily washed out, when there is a certain quantity of water accumulated at lake. Moreover, dyke formation may occur several times within a short period and breakthrough of each dyke causes a catastrophic flood, which is transformed into a mudflow. The Medvezhiy glacier at the Vanch river basin *(Photo 25)* is a bright example of such pulsating glacier. We consider regular pulsations of that glacier to be related to the structure of its feeding and transit. A glacier circus is terminated with rather high and steep icefall. When surplus ice accumulates in the circus, it starts moving, as ice acquires plastic properties at a certain capacity. The ice mass protrudes to the bench and falls down to the glacier "body", which also starts moving due to being additionally loaded with a falling mass. We find a confirmation for this by the example of the Russian Geographic Society (RGS) glacier, which is close the Medvezhiy glacier. In the beginning of 2005 a glacial snow slide took place at one of the RGS lateral glaciers, which fell down on the glacier body and additionally loaded it *(Photo 26)*. As a result, while making measurements in 2005, it was determined that the RGS glacier started moving.

9. Evaluation of the Mountain Lake Breakthrough Risk. Evaluation methods

A mountain lake breakthrough risk is evaluated by S.A. Yerohin and O.A. Poderzov under three categories as follows:

1st category – the lake is located at the breakthrough stage and protective and preventive engineering methods are required to be held for avoiding possible catastrophic consequences of the breakthrough;

2nd category – in its development the lake is approaching the breakthrough stage, however, for the time being there is no direct threat; secure control is required at lake;

3rd category – the lake has got preconditions for the breakthrough in future, however, presently there is no threat. The lake is to be monitored on a yearly basis with aero-visual surveys.

Evaluation of the lake breakthrough risk by categories allowed to work out recommendations eliminating or minimizing the lake breakthrough risks. Recommendations came to the following:

1. To hold dam overland survey at the most breakthrough risky lakes in order to identify a breakthrough mechanism and to estimate a breakthrough flow rate;
2. To inspect mudflow centers, along a breakthrough flow way;
3. To profile mudflow risky mountain valleys in order to identify mudflow and flood zones;
4. To undertake various preventive actions against lake overfilling;
5. To construct mudflow diverting dams;
6. To construct mudflow stores and protective dams.

Specific features of breakthrough risky lake assessment per each genetic category are considered individually by example of certain most typical lakes.

A.A. Yablokov

Medvezhiy glacier pulsation

1963

The glacier has increased by 1 700 meters lengthwise and 1.7 km^2 in area; the volume of protruded ice comprised 140 mln.m^3. By 18 June 1963, 21 mln m^3 of water was accumulated in the impounded lake; under the glacial dam it opened the way to itself and a mud-flow streamed down along the Vanch river. It had a discharge capacity of up to two thousand cubic meters per second – it is seven times higher the maximum rate of the Vanch River at the height of snow and glacier thawing! The total damage amounted to more than 1.5 bin rubles. No victims were recorded. In day and a half, only three million cubic meters were left in the lake, the tunnel under the ice dam crumbled, the new impoundment of the natural water reservoir started again. By the end of June, 15 mln. km^3 of water has been accumulated and a new breakthrough occurred, however, it was weaker against the first one.

1973

This time the pulsating glacier has become elongated by 175 m versus 1963; the height of its frontal part ran up to two hundred meters, and the capacity of protruded ice amounted to 184 mln.m^3: this was one of its most powerful "dashes". On 19 June, when in the lake 27 mln m^3 accumulated, and it was 110m deep, breakthrough of the lake occurred. Maximum discharge rate amounted to almost thousand cubic meters of water per second. At the same time, the Vanch River level in the regional center rose up by three meters, and the Pyandj River level (180 km far from the glacier) in Kalaihumb town rose by one and a half meter. After the dyke has been broken, the situation recurred: when in the lake three million cubic meters were left, the tunnel closed, the lake was refilled, and on 7 July, 1973 a second breakthrough occurred. And the mudflow discharge rate amounted to two thousand cubic meters per second, water-level in the Vanch River rose by six meters. However, this time also the mudflow has not made great damages as the population learnt to control it.

1989

During that "dash" the Medvezhiy glacier protruded by 1.2 km and increased its area by 0.8 km^2, the capacity of protruded ice comprised about 80 mln.m^3. But the height of icy dyke turned out to be significantly lower than usually, that is why a dammed up lake was less than the former lakes, its breakthroughs occurred several times and were not strong. Impoundment of the lake started on 16 June, and already on 26 June the first breakthrough with the discharge rate of 60 m^3/second occurred. By that time the lake capacity has just reached 4 million cubic meters. The second breakthrough with discharge rate of 120 m^3/per second occurred at the night from 27 to 28 June. Such mudflows occurred along the Vanch River actually insensibly. The lake reached its maximum capacity of 6.1 mln.m^3 by the 5th of July, but not more than 50-60 m^3 per second broke through from the glacial tunnel. Those breakthroughs did not make great damages.

While the next movement in 2001 – 2002 the Medvezhiy glacier did not overlap the Abducagora valley and the lake was not formed.

9.1. Models of Mountain Lake Breakthroughs. Estimation of the Breakthrough Flow Rate

For estimation of the breakthrough flow rate it is necessary to be aware of the mechanism of the lake breakthroughs as well as to know values of a number of estimated parameters specifying dam and lake bath structure. The lake breakthroughs are diverse due to a breakthrough nature, however, according to the main mechanism of water discharge from the lake through a dam body they are divided into two types: underground and surface. According to the model of the first type water is discharged through the underground channel (maybe, through a wide network of channels) in the lake dam body. According to the second model water is discharged by spill over a dam ridge in the cofferdam are with an erosive wash-out of the latter one.

Underground Lake Breakthrough. With such breakthrough mechanism a model of manifold pipeline comprised by relatively short pipes of various diameter and roughness with multiple contractions, expansions and twists is used for estimation of the breakthrough flow rate. With such structure of run-off channels local and directional hydraulic resistances result in great losses of flow energy that is displayed in its velocity reduction and, thus, drop of the rate. The longer the underground run-off channel is, the less a breakthrough flow rate is. In fact, the breakthrough flow rates under observation in outlets of the run-off underground channels in general did not exceed 10mVsec, and rarely achieved 20-30m^3 /sec. A breakthrough flow rate impacts the run-off channel sides and roof. That impact nature is mostly erosive-abrasive, however, a thermo-karst process is added thereto.

If a breakthrough flow rate exceeds a critical value, its impact on the run-off channel may turn out to be so significant that destruction of the latter one starts. In this case the lake dam slumps begin along a run-off channel, and a closure channel is formed at the cofferdam ridge, through which the surface lake breakthrough occurs. With this option the breakthrough flow rate increases up to hundreds of cubic meters per second.

The surface lake breakthrough does not always result from the underground breakthrough, but may be formed without involvement of the underground run-off channels. For the lake surface breakthrough the closure channel formation is required in the cofferdam ridge. Reasons for the closure channel occurrence are different: 1) slumping of the cofferdam ridge over the underground run-off channel; 2) cofferdam washout during water slipover from the lake; 3) dam slump during earthquakes. During surface breakthrough the flow velocity is not limited with hydraulic resistances of underground run-off channels, that is why reaches 3-4 m/sec, ensuring the strengthening of erosive impact on the dam and destructing of the latter. The great flow velocities, run-off wide and deep closure channels (under erosive impact of the breakthrough flow of the closure channel are deepened and extended) stipulate for the formation of powerful breakthrough flows with a rate amounting to several hundreds – several thousands cubic meters per second.

In order to identify a breakthrough flow rate it is required to get aware of the lake breakthrough mechanism, as well as to know values of various estimation parameters, specifying dam and lake bath structure. Estimations for the identification of the breakthrough rate are made in accordance with "Methodology for Identification of Flood and Mudflow Damage Areas during Mountain Lake Breakthroughs"(Methodology. 1998).

Detailed researches have been held in Tajikistan on the possible Sarez Lake breakthrough. Calculations have been made of the size of the wave, which can fall upon the dam, flood elevation, which can be caused by this wave, identification of areas damaged by the flood along the Bartang River valley. The Sarez Lake served as a ground to workout a methodology for estimation of natural dam breakthroughs. Besides Soviet specialists, similar estimations for the Sarez Lake were made by Swiss Stucky Consulting Company, which made surveys under the World Bank request. The options for location of risk zones were thoroughly worked over with discharge of the breakthrough flood amounting to 1000m^3/sec and 5000m^3/sec; the risk maps for all the inhabited areas of the Bartang River valley were drawn. All calculations were based on the wave elevation value, which may overflow a dam ridge, and depending on this flood models were build and dimensions of risk zones in the Bartang River valley were identified. Calculations for zones of flood damage during catastrophic destruction of the Ussoy logjam body have not been made, proceeding from condition of the dam stability.

Researches related to the forecast of the estimated wave regime at the Sarez Lake, resulting from the sudden collapse of huge rock masses into the lake from its slopes, were made by "Soyuzgiprovodhoz" Institute, on the physical (hydraulic) models and mathematic modeling applying computer program, which was developed by SANIIRI Institute (Tashkent). Models, describing motion of long waves in open beds in the undimensional arrangement and based on Sen-Venane assumptions (hypotheses) were used to build mathematic models.

The research results are given in the initial report "Mathematic Modeling of Displacement Waves, Caused by Landslide Phenomena at the Sarez Lake", the main conclusions of which are as follows:

1. With the landslide capacity decrease, both wave elevation and spillover capacity decrease as well.
2. With the decrease of the spillover elevation and capacity, its power decreases as well. For example, if the wave amplitude decreases from 150m up to 100m and 50 m the power decreases 3 and 12 times. That is why the less wash-outs on the Ussoy dyke are to be expected,
3. With the landslide capacity of 0,35 km^3, there won't be any serious consequences. If the maximum possible landslide capacity is taken into consideration or 0,9 km^3, the wave gush into the Bartang River valley is to take place at the capacity of 70-80 mln m^3 (a part of the capacity is accumulated in the Shadau Lake).The Ussoy logjam wash-out will be within the range of up to 10m.; the gush wave is to be transformed in the Bartang River valley.

Despite researches undertaken the estimated dam breakthroughs models are not to be applied in the development of project measures for the Sarez Lake, as far as it is not well known, with which grounds and rocks the logjam ridge is formed. And without all these aspects it is impossible to assess how deep it may be washed out by the wave spillover, as well as its general stability against wash-outs.

Swiss Stucky Consulting Company has thoroughly studies this issue and the correspondent methods. Data used by the company experts may be applied for estimation of the impact of flood caused by the spillover wave during the mountain lake dams breakthrough.

Table 7. Comparison of results of the spillover wave modeling

Mudslide capacity, cub km	Mathematical model		Physical model	
	Wave elevation, m	Spillover capacity mln.cub.m	Wave elevation, m	Spillover capacity mln.cub.m
0,15	35	16		
0,3			50-60	30-50
0,6	87	47		
0,8	107	88		
0.9	115	107		
1			100-125	70-110
2	180	225	150-175	145-170

Photo 3. The Teketor moraine-glacial lake on the northern slope of Kyrgyz mountain ridge

Photo 4. The Petrov moraine-glacial lake in the Upper Naryn.

Photo 5. The Kutmankul logjam lake in the Mailisay upper basin

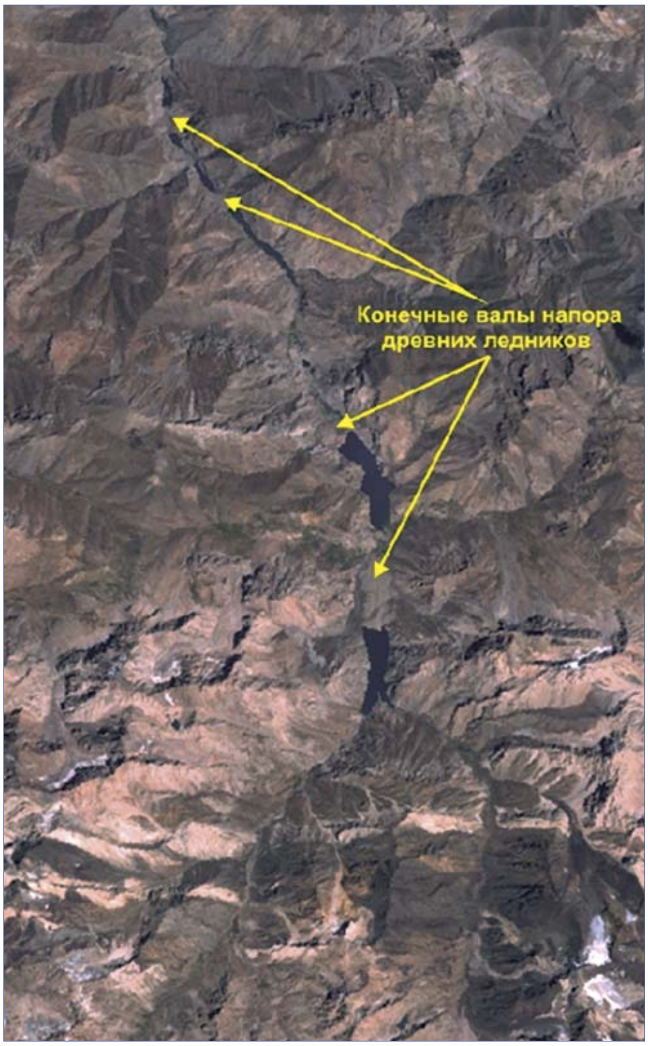

Photo 6. The Marguzor lakes in the Shing River basin (Zeravshan)

Photo 7. A logjam at the Yashirkul lake in the Eastern Pamirs

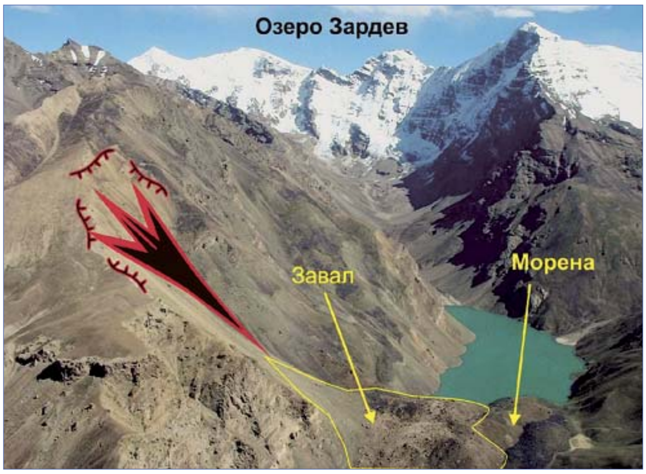

Photo 8. A composite dam on the Zardev Lake of the Shakhdara River valley

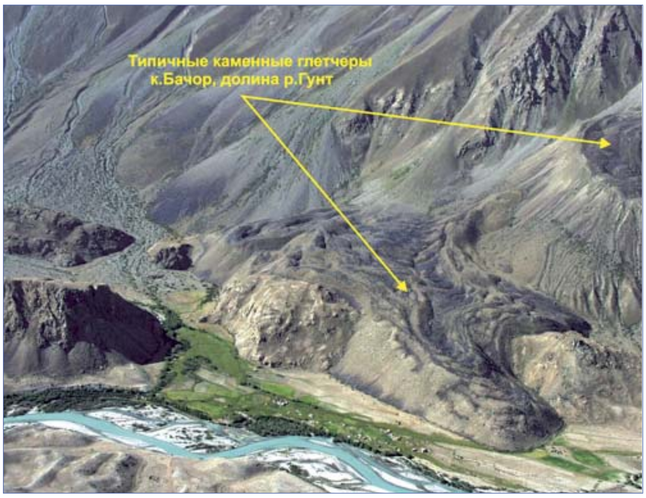

Photo 10. Mountainous-valley stone glacier creeped out into the main valley.

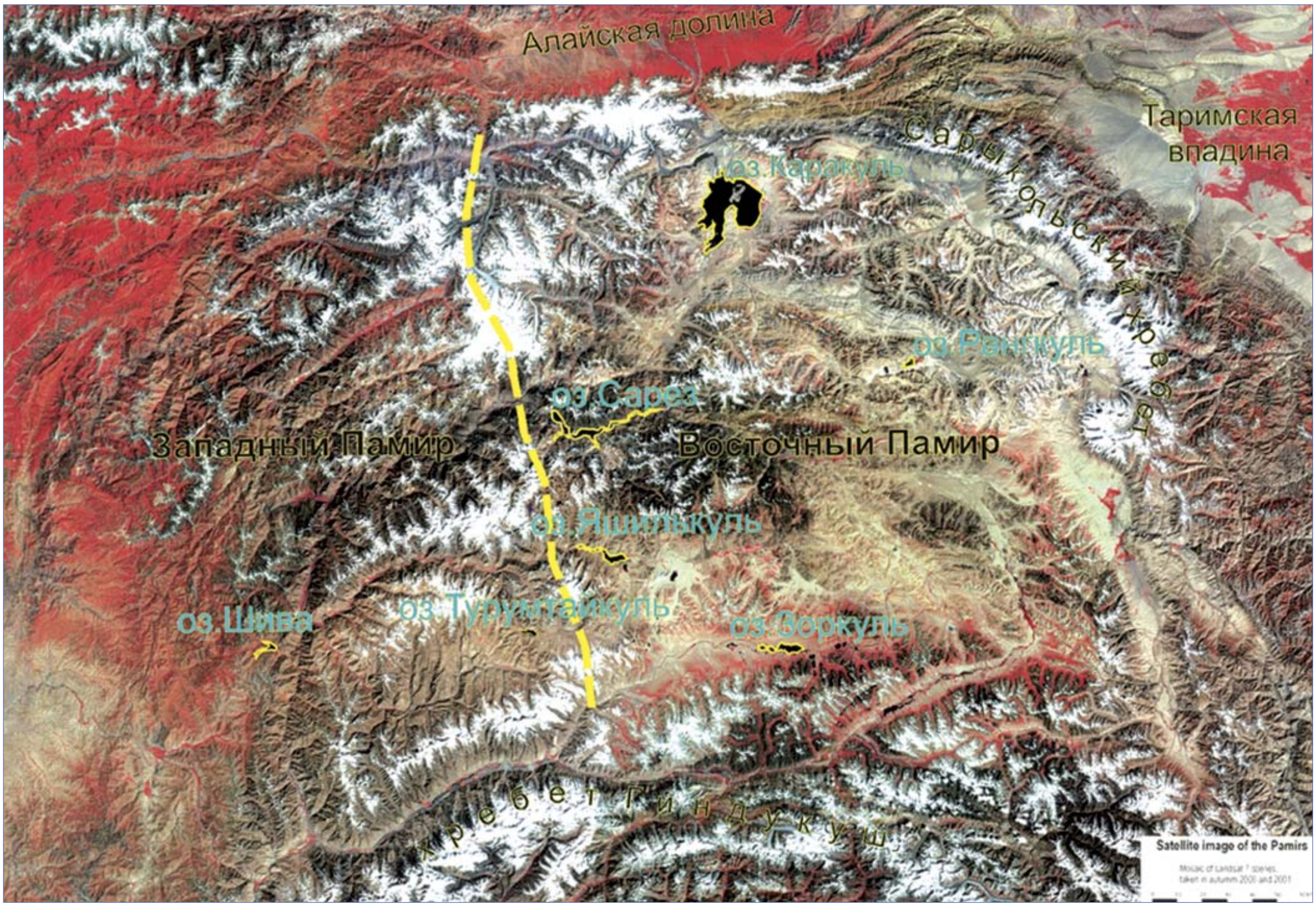

Photo 9. The Pamirs from the outer space

Photo 11. Mountainside stone glaciers and subsidence terraces of ancient glacier.

Photo 14. The Usoy logjam at the Sarez Lake

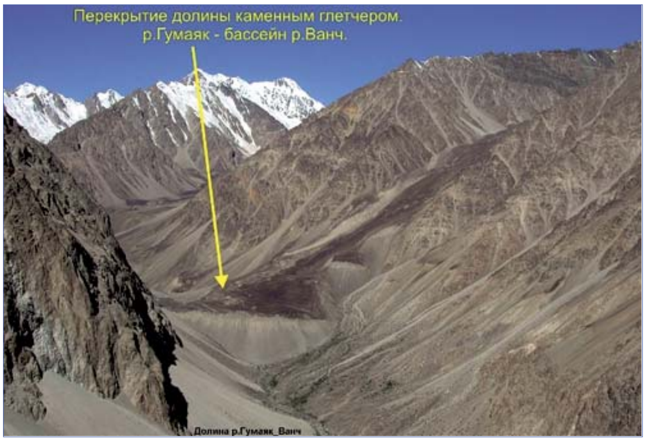

Photo 12. Overlapping of valley with stone glacier.

Photo 15. A logjam at the Iskanderkul Lake

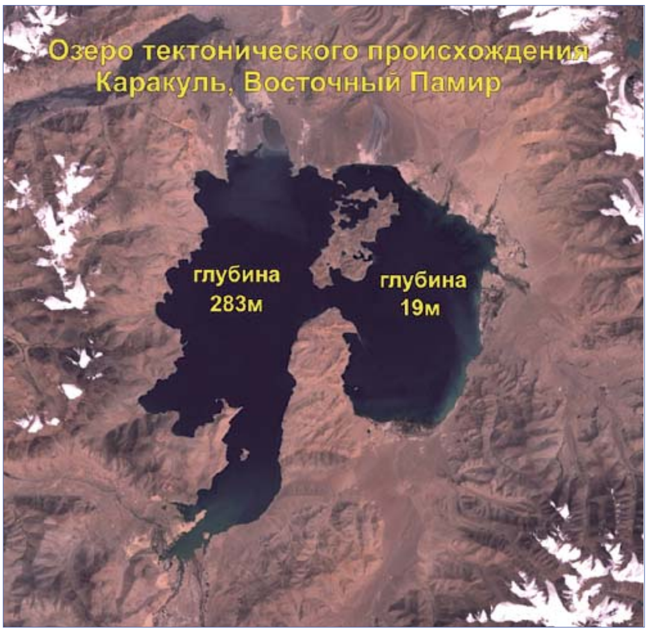

Photo 13. The Karakul tectonic origin lake in the Eastern Pamirs

Photo 16. A Composite dike at the Zardev Lake

Photo 17. The Drumkul Lake in the Shakhdara River basin.

Photo 20. A composite dike at the Kharkul Lake

Photo 18. The Kulikalon Lake among moraine relief.

Photo 19. The Marguzor Lake in the Shing River basin

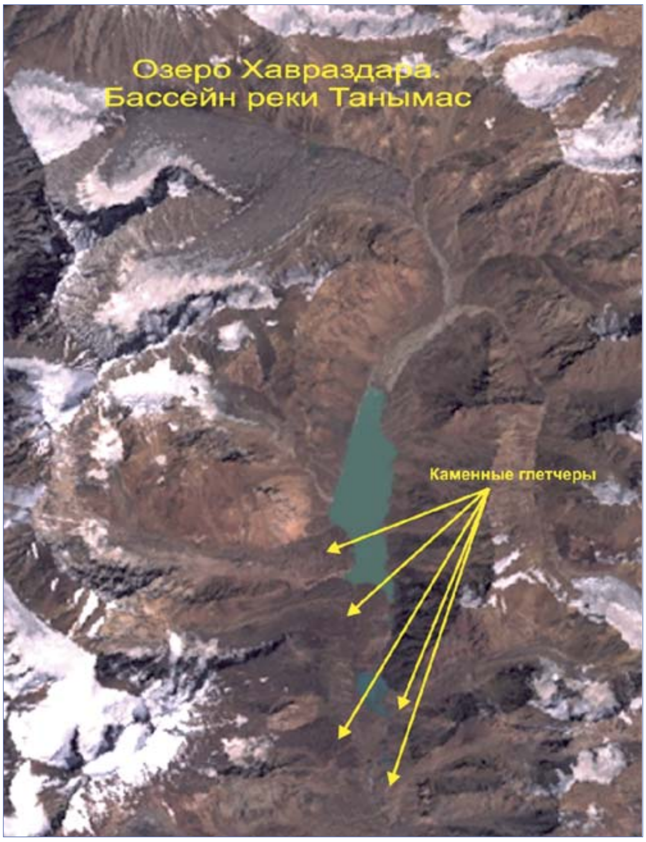

Photo 21. Several stone glaciers, which formed the Khavrazdara Lake.

Photo 22. A thermo-karst lake in the terminal moraine ridge

Photo 23. Series of thermo-karst lakes on the Bivachny glacier

Photo 24. TheTurumtaikul Lake in the glacial depression

Photo 25. A recurrent motion of the Medvezhiy glacier

Photo 26. A glacial avalanche slipped down onto the RGS glacier

9.2. Identification of the damage area of the breakthrough flow

The identification of the breakthrough flow damage area is required to undertake protective measures, eliminating or at least minimizing mountain lake breakthrough risk. The methodology of such identification is based on the fact that processes related to the lake breakthrough, such as mudflow formation, mudflow and flood flow motion and interrelation with sides and bottoms of mountain valleys are considered in the close correlation as individual fragments of uniform multi-factor natural phenomenon, namely, a mountain lake breakthrough.

A breakthrough flow, while moving down along the valley, covers either the whole width of its current bottom, or a part thereof, depending on the valley morphology (inclination width, availability of overfloodplain terraces), its geological structure (composition of rocks and sediments forming sides and the bottom), hydrological nature of the flow (flood or mudflow). Thus, in order to identify width of the flow, and, thereby, damage area borders, it is necessary to take into consideration morphological, lithologic and hydrological factors of the breakthrough flow formation on each certain site of mountain valley. At the same time, the role of each factor in general process is estimated by correspondent parameters: a morphological factor – with the width of current valley bottom and its inclination; lithologic – with the density of the breakthrough flow; hydrological – with flow discharge.

For identification of mentioned above parameters transversal and longitudinal valley profiles are built, where morphology of its bottom and adjacent to it sides is presented, and the composition of rocks and sediments making them up is specified. According to every transversal profile the following parameters of the breakthrough flow are estimated: rate, density, elevation. In accordance with the breakthrough flow elevation its width is estimated, which is exactly the damaged area width at the given part of the dam. Thus, profile by profile we are able to identify the borders of the breakthrough flow damage area Examples of such areas are shown in *Photo 4*.

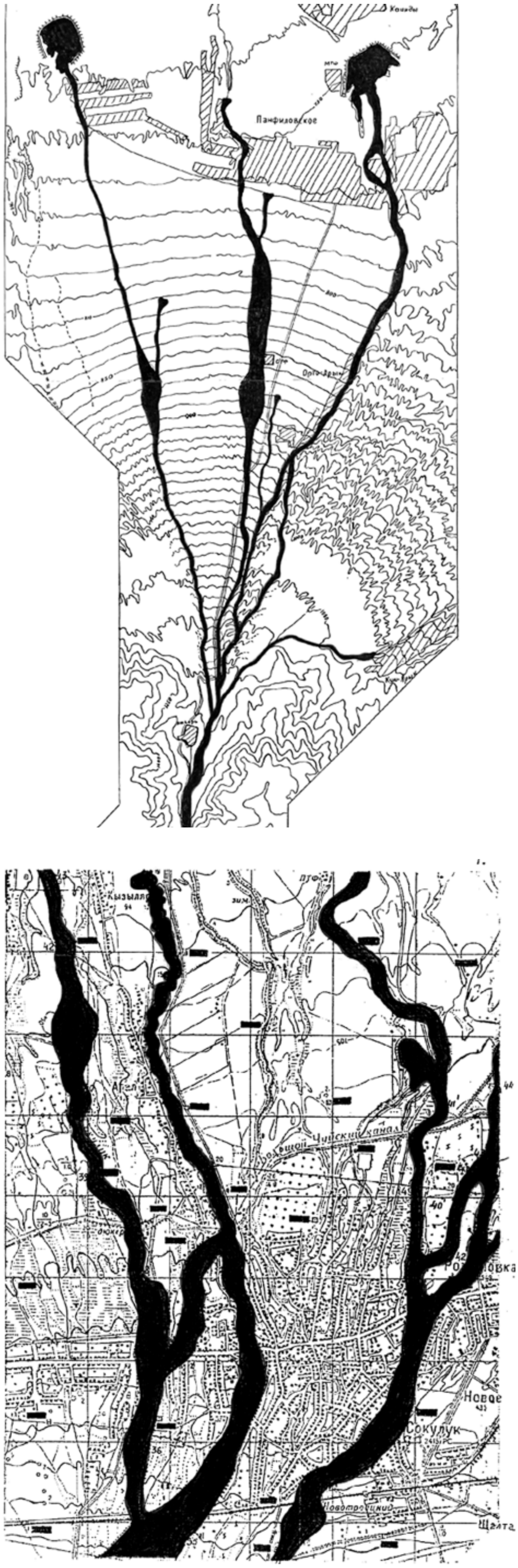

Fig. 4. Damage areas of: *1* – Panfilov village during the Jardy-Kaindy Lake breakthrough; *2*- Sokuluk village during the Keidy-Kuchkach Lake breakthrough.

Reasons of water level rise in lakes

Reasons of water level rise in lakes, pounded by natural dams, are as follows:

- Sharp change of climate conditions, intensification of solar radiation causing ice and snow thawing in the catchment areas.
- Intensive thawing resulting in the development of thermokarst processes in glacial dams and in glacier body contributing to the lake formation.
- Intensive precipitations, which occur within abnormal years resulting in water spillover through dyke.
- Decrease of natural infiltration through moraine dyke due to the mudding of dyke body with clayey particles, being present in water, or due to dyke densification caused by earthquakes and processes of fine filler firming as a result of its moistening.

Mechanisms of dyke destruction and breakthrough

A lake dyke may consist of glacial ice or moraine, consisting of fine fragmental material and big blocks, either with glacial kernel or without it.

The following mechanisms of destruction are known:

- Mudslide, landslip or a part of glacier itself slip down into the lake and create a wave, which spills over a dyke and dyke erosive destruction occurs.
- A melkozem protrusion from the body of moraine dyke (suffosion) by filtration water that causes increase of filtration, subsidence in the dyke body and, as a result, dyke destruction with erosion.
- Channel formation on or inside the ice due to thermo-karst processes (thermokarst), through which the catastrophic water discharge out of the lake occurs.
- Thawing of dyke glacial kernel resulted in reducing the dyke efficient elevation and stability.

Table 8. Breakthrough risk lakes in Tajikistan

Lake name	Author	Year of survey	Breakthrough reason
Marguzorskiye	V.D.Fomenko	1967-1968	Lake landslips or mudslide
Lake at the Upper Varshidzdara rive	–II–	1967-1968	Glacier motion
Nematskul	–II–	1967-1968	Side landslips
Rivakkul	–II–	1967-1968	–II–
Huumetskul	–II–	1967-1968	–II–
Drumkul	–II–	1967-1968	–II–
Zardev	–II–	1967-1968	–II–
Havrazdara	–II–	1967-1968	Mudflow
Rivakkul	J.Shneider	2002-2003	Breakthrough of 5 upper-laying lakes
Zardev	–II–	2002-2003	Mudslide
Drumkul	–II–	2002-2003	–II–
Hidorjevdara	–II–	2002-2003	Spill over the dyke
Sharfdara	–II–	2002-2003	–II–
Dashtara	–II–	2002-2003	New lake formation
Sharipdara	–II–	2002-2003	Spill over the dyke
Pishdara	–II–	2002-2003	–II–

E. A. Yerohin

Breakthrough risk lakes of Kyrgyzstan

As a result of aero-visual survey of Kyrgyzstan territory in 2000-2004 the following breakthrough risk lakes have been found out by regions:

Issuk-Kulskaya *– 66 lakes; covering 13 lakes of the 1st category & 8 lakes of the 2nd category;*

Chuyskaya *– 34 lakes, covering 2 lakes of the 1st category & 8 lakes of the 2nd category;*

Narynskaya *– 9 lakes, covering no lakes of the 1st category & 3 lakes of the 2nd category;*

Talasskaya *– 17 lakes covering 2 lakes of the 1st category & 3 lakes of the 2nd category;*

Jalal-Abadskaya *– 15 lakes, covering no lakes of the 1st category & 1 lake of the 2nd category;*

Oshskaya *– 41 lakes, covering 3 lakes of the 1st category & 4 lakes of the 2nd category.*

Totally*: 182 lakes; covering 21 lakes of the 1st category and 27 lakes of the 2nd category.*

According to the location of breakthrough risk lakes on the territory of Kyrgyzstan, 10 zones of their concentration have been identified: Eastern-Terskeyskaya – 26, Central-Terskeyskaya – 17, Western-Terskeyskaya – 9, Kungeyskaya – 19, Kyrgyz Ridge zone (Chuyskaya) – 29, Talasso-Chatkalskaya – 20, Central-Talasskaya – 6, Eastern-Alayskaya – 16, Central-Alayskaya – 10 and Western-Zaalayskaya – 8 lakes. Lakes of each zone are united into one group. The group names coincide with the area name. Besides 10 groups of lake concentration, there is a group of separate lakes, which are scattered on the Republic territory in one or 2-3 lakes. There are 22 lakes in the group of scattered lakes.

Dykes with a great deal of ice, both in a free form and as cement are mostly subjected to destructions. Moreover, granulometric composition of the dyke body plays a significant part in the dyke wash-out velocity. The more there are fine fractions in the dyke body, the faster it is washed out. Availability of coarse lumpy component greatly decreases erosion process and suspends dyke destruction (for example, the Drumkul Lake dyke).

A very dangerous situation arises, when a series of lakes is located as a chain along a river valley that may cause accumulation of the breakthrough flow capacity while it goes through each lake (for example, the Marguzor lakes in the Shing Lake basin).

Summarizing the aforesaid the following may be noticed. In mountainous territories of the CA countries the predominant amount of mountain lakes is somehow related to a powerful glaciation formation and degradation, which had several stages of retreat and incursion. There were no interglacial periods, when all the glaciers disappeared. During glaciation degradations (stages) lakes were formed and during glacier incursions they were destructed. During the next glacier degradation lakes arose again *(Photo 27).*

As far as during each stages glacier incursions declined, the lakes, which were located in chain behind the terminal ridges of retreating glaciers, were formed in valleys under favorable conditions. Not in all valleys behind the terminal ridges of glaciers the lakes survived. Some of them were drained because of the dyke destruction *(Photo 28)*, the other survived due to the subsidiary impoundment with slope gravity deformations or moraine dyke structure (for example, the Drumkul Lake in the Shakhdara River valley).

The pre-glacial lakes are the most dangerous of all the types of mountain lakes. One of the reasons of this is retreat of the glacier. In the terminal part of the glacier the lakes arose, in which sometimes a part of the glacier intrudes *(Photo 29)* or slivers *(Photo 30)* that results in the slow or catastrophic spill of water out of the lake (as it, for example, occurred in the Dashtdara River valley of the Shakhdara River basin in 2002). That is why specific attention is to be paid to pre-glacial lakes as the most risk ones.

Another aspect of the mountain lake breakthrough, which is paid insufficient attention at, is the impact of slope gravity deformation in the lake basin. Soil failure into the lake water area may provoke water spill over the dyke, which may cause a mudflow lower the dyke or destruct dyke itself. This may result in more powerful flood. This problem aspect has not been studied for Tajikistan mountain lakes (except the Sarez Lake). During reconnaissance surveys of mountain lakes *[45]* such breakthrough possibility has been revealed only for some lakes, and it was suggested to more thoroughly study those lakes

During studying the whole material on Tajikistan mountain lakes, a list was made of lakes, which were considered by survey experts to be of breakthrough risk.

It should be noted that the list submitted does not reflect the real situation, as far as the mentioned lakes have not been thoroughly studied and everything is based on the researches personal experience. Till nowadays there hasn't been any clear picture of the mountain lakes' status; the most dangerous of them have not been revealed. Currently, there are lakes, which were not reflected in the topographic maps previously made, i.e. they have appeared within the latest 15-20 years and some of them already contributed to natural disasters. For example, on 30 August 2003, a mudflow occurred in the Sharipdara River basin (the Gurt River valley); it destructed a path and bridges in the river valley. The mudflow was caused by breakthrough of a pre-glacier lake, which was not depicted on the topographic map. That is why there is a necessity to make inventory of all the mountain lakes, especially of glacial ones, on the basis of up-to-date high resolution space images. Only following those actions, it will be possible to start thoroughly studying breakthrough risk mountain lakes and later prove offers for eliminating the risk, which may arise due to its breakthrough.

10. Measures undertaken to minimize and to prevent a mountain lake breakthrough risk

Regular inspections of all the lakes, including mountain ones, were held in the USSR. Moreover, it was done by two agencies: geological and hydrometeorological. Annuals, books and articles devoted to mountain lake problems were published. A mudflow risk of mountain lakes, a breakthrough possibility thereof, destruction risk and stability thereof were assessed. Lakes, which may endanger population of subjacent river valleys, have been identified. But after the USSR collapse those works have been stopped or greatly reduced. In Tajikistan studying of the breakthrough risk in mountainous lakes have not been really held for 20 years. Some works regarding this trend are held in Kyrgyzstan. Material with studies of factors of mountain lake formation has been accumulated in Tajikistan. Investigation of overburdens and geomorphology during 1984-1989 allows revising types of mountain lake dams and making a conclusion that formation of the majority of them is related with the formation and disruption of the upper quaternary glaciation. This, in its turn, allows estimating their stability and breakthrough risk from the new point of view. New researches, involvement of the space images, geographic and geological research methods are required for this purpose.

Regular planned investigation of mountain lakes of breakthrough risk in Kyrgyz Republic has been started since 1966 after a catastrophic breakthrough of the Yashilkul Lake in the Isfairam River basin on 18 June, 1966. On 15 August, 1966 a decree of the Cabinet of Ministers of Kyrgyz Republic was issued on the necessity of survey of Kyrgyzstan's mountain lakes in order to prevent a risk of mudflows. Implementation of that decree was committed to hydrometeorological and geological agencies. Nearly 250 lakes have been

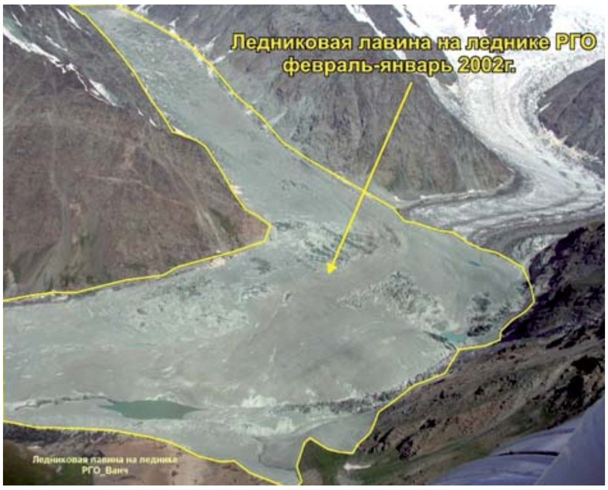

Photo 27. Swells of the moving glacier head behind which lakes are formed after ice thawing

Photo 29. A glacier advance into the lake.

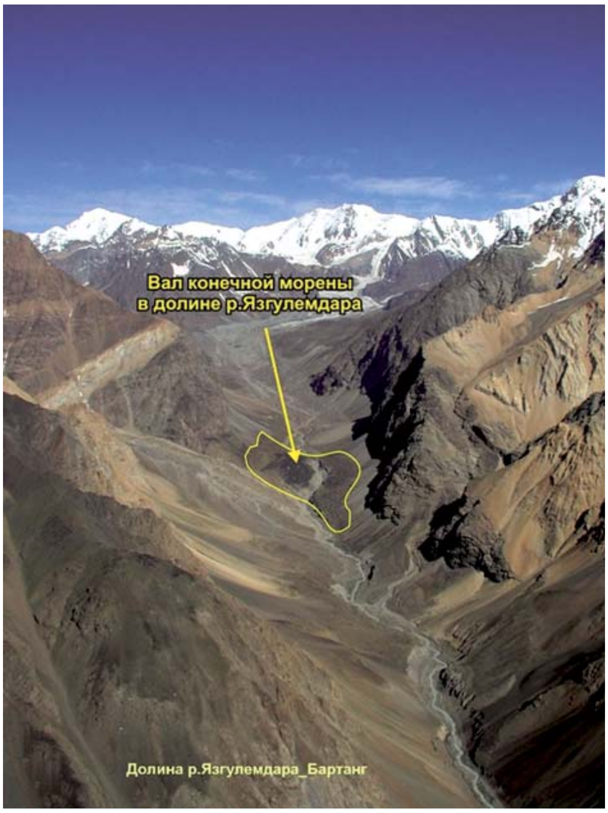

Photo 28. Washed out terminal ridge with a head swell in the Yazgulemdara River valley

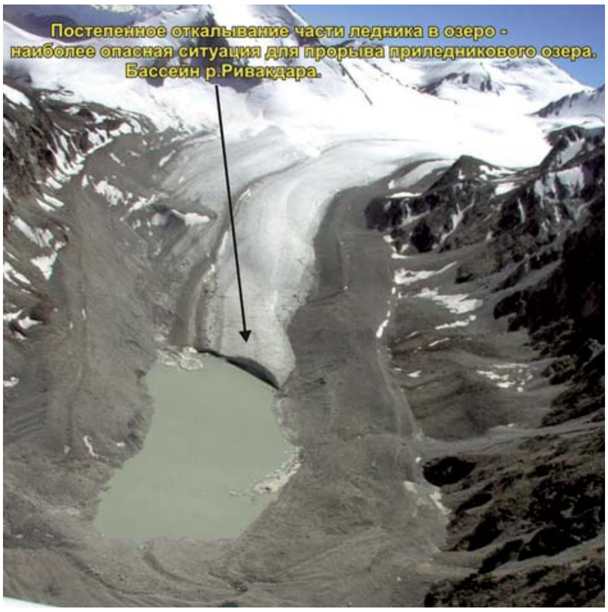

Photo 30. A glacier with a tongue part being broken off

studied within this period till 1992; a monitoring basis has been laid.

The monitoring included:

1) aero-visual survey (from helicopter) of the republic territory in order to identify lakes, being in their development stage of the breakthrough risk. Number of trial flights is 5-6 during the dangerous period from June till September;
2) Surface survey of dams and baths of the most breakthrough risk lakes to identify a breakthrough mechanism, to estimate a breakthrough flow rate, to assess the risk and to work out actions for its elimination.

The surface survey included the following types of work:

- topographical survey of lakes and dykes;
- engineering-geological survey of dykes;
- bathymetric measurements of lakes;
- operating control of fluctuations of the lake level, water inflow and run-off;
- geophysical probing of the dyke;
- uranium-isotope study of the lake feeding source.

Because of insufficiency of funds the works for mountain lakes investigation have been completely stopped by Kyrgyzstan HydroMeteoAgency since 1992. They are surveyed by the Geology State Agency within the latest 14 years (since 1992 till 2006) involving MLS. At the same time, those works are insufficient in their efforts and have occasional nature. The yearly aero-visual surveys have been arranged since 1996 till 2003, with a small scope of field inspections at some lakes of a logjam type.

The insufficiency of financial resources has changed methods of lake study, excluding such expensive researches as topographic survey, geophysical probing, operating inspections and uranium-isotope probing.

At the same time, surface inspections based on work results of past years still allow tracing lake development dynamics in some regions, such as Chuyskaya, Talasskaya, and northern part of the Issyk-Kul area.

At present there are 182 breakthrough risk lakes in total in Kyrgyzstan, covering 21 lakes of high danger (1st category), 27 lakes of mid danger (2nd category) and 140 lakes of low danger (3rd category)

Besides studying mountainous lakes, the Republican MES undertakes anti-flood measures, which include river-bed diking, river bank strengthening with gabions and dams, construction of anti-mudflow protective dams.

Since 1990 till 2002 Tajikistan lakes have not been studied. A small and relatively short glacial expedition of 2005 found out shallowing of the Eastern Pamirs lakes such as Rangkul, Shorkul and Sasykkul. In the middle of June 2006 together with employees of HydroMeteoAgency of Republic of Uzbekistan they flew around the Zeravshan River basin, where they surveyed the complex of lakes in the basins of the Shing (Mariandaria), Zindan (Kshtut) Rivers, Kulikalon lakes, lakes in the Upper Pasrudarya River, as well as small temporary lakes at the surface of Zeravshan, Rama, etc. glaciers. The same year a foot inspection of Timurdaraand Payron lakes at the Upper Karatag River was undertaken. It was found out that the level of those lakes has not changed during the last years, and no one is in danger of a breakthrough.

In 2002 the consequences of the mudflow, which slid at the Shakhdara River basin was inspected. A breakthrough wave from a glacial lake caused enormous mudflow with the total capacity of 1.2 million m^3 of sediments, which partially destroyed Dasht kishlak and was a reason for loss of 24 lives. In order to investigate that event specialists from Applied Geology Institute (IAG-BOKU)/Vienna have been invited. Jointly with local specialists they inspected the Dasht River valley. It was found out that the mudflow was caused by displacement of a part of the glacier into the glacial lake, resulted in water overflow from the lake and mudflow formation. In 2003 the same group of experts inspected the Southern-Western Pamirs lakes and assessed a breakthrough risk thereof *[40]*. 278 lakes have been classified in total. A lake breakthrough risk was assessed comparing various space images, as well as aero-visual and field survey data.

J. Shneider

Potential threat of breakthrough at some lakes of Pamirs

"A large-scale event is likely to be expected as a result of the breakthrough of the Rivakkul, Zardev and Drumkul lakes. Those three lakes have got a great water capacity and dams with water filtration and seasonal overflow. The breakthrough of mountain lake dams or mass motion into those lakes is quite possible. The possibility of dam breakthrough of those main lakes is within low-average range, as far as only large seismic activity may cause the overflow, which may result in the dam partial destruction. The glacial lakes at the Upper Rivakdara and Varshidsdara (the Gunta valley) are characterized with a great breakthrough probability, however, it is impossible to foresee time and dimensions of the breakthrough. It is one of the reasons due to which lakes are considered to be hazardous. It should be supposed that in case of breakthrough, those dams would be completely washed out, and the lakes would be drained. Mass motions, mudflows or flood waves originated on the Afghani bank of the Pyandj River may greatly damage infrastructure located on Tajik bank of the river. Therefore it is required to undertake transboundary researches of local and remote geological threats originated on the orographic left bank of the Pyandj River».

Within the same period, potential remote geological threats posing hazard for the Pyandj River valleys, centers of origin of which are located in the left tributaries on the Afghanistan territory and are not studied yet, have been found out. It was assumed that they are of the most risk for the population living at the Upper Pyandj River.

Critical areas *(Table 9)* have been identified as a result of the works undertaken and recommendations were given to arrange monitoring thereof *[40]*.

Table 9. Locations with a high breakthrough risk and gravity mass motion potential

Locations with a high breakthrough potential of a glacial lake or flood have been distributed in accordance with the lake type and dimensions, maximum water discharge & possible impact on areas located downstream	• Rivakdara &VarshidzdaraattheGung River valley; • Sezhddara (Zardev) & Drumdara at the Upper Shakhdara • Khidorjevdara, Sharfdara and Dashtdara at the Upper Shakhdara River
Locations with potential risk of mudslides & active subsidence (deep gravity creep)	• Shakhdara River close to mentioned below kishlaks (mostly located at the southern side of the valley): Shikup, Sumjev (Tavdem), Nudg, Namadrog, Dashtak, Barodj, Rastarez, Jorsh, Midanved, Bidiz, Shivoz, Bezgin, Sindev.
Locations exposed to big stone-falls or landslips	• Shakhdara River before tectonic break-up zone between Sovetabad and Nimos, covering Badjomdara, Chandimdara & Drundara tributaries.

11. Conclusions and recommendations

Despite of the fact the CA lakes study is of over one hundred year history, a reliable list of breakthrough risk mountain lakes has not been identified till present. The mountain lakes have not been thoroughly studied regarding a breakthrough risk thereof. The lakes were and still remain insufficiently studied from the point of view of stationary and systematic lake science researches. The data on such specific lake researches as wave height, currents, alluvium transformations, in washing and silting, bank reformation, possibilities to form slope gravity deformations along the lake perimeter and their impact on dam stability are not available at all.

At the end of the last century only the Sarez lake has been properly studied, a lot of projects having been devised for it to minimize its breakthrough risk; though none of them were implemented. It is again related to the insufficient study of the Usoy logjam structure itself. Till present nobody can give a uniform reply whether the catastrophic breakthrough of the lake may occur or not.

A planned study of breakthrough risk of the CA mountain lakes started in 1960s and lasted till the USSR collapse. No researches of mountain lakes have been conducted during 15 years. There is no generally recognized classification of mountain lakes according to their formation conditions and their potential danger. The researchers have got various classifications, which are generally close to each other, but differ per some prevailing factors and formation conditions thereof. The reliability of the lake further development forecast depends on the correct identification of lake formation.

In CA mountainous areas the prevailing number of mountain lakes are somehow related to glaciation formation and degradation, which is characterized with several transgression and regression stages. Global climate warming causes retreat and reduction of the present-day glacier that in its turn, results in formation of new breakthrough risk lakes.

Following the USSR collapse the system of monitoring and forecast of environment and development dynamics of natural phenomena and objects has greatly declined. Financing of the state specialized organizations responsible for environment monitoring has been reduced. The CA countries' capacity building occurs depending on the situation with overcoming economic difficulties.

In this connection, CA countries have achieved success of a variable extent in working out plans to respond extraordinary situations.

At present, the policy of extraordinary situation of CA countries contains regional mechanism acting on the basis of collaboration between CIS countries within the frameworks of Interstate Extraordinary Situation Council for natural disasters and man-made catastrophes, and which requires to be improved.

Recommendations:

- To develop a uniform system for assessment of risks and responses to the possibility of mountain lake breakthroughs within the framework of the Central Asia region.
- To develop integrated approaches to the planning of actions in case of mountain lake breakthroughs at the national and regional levels.
- To develop system options for monitoring breakthrough risk mountain lakes (depending on resource availability). – To create information network for information distribution among the local population and decision-makers about potential threat of mountain lake breakthroughs and possible measures for its mitigation.
- To introduce a risk insurance systems against extraordinary situations (including mountain lake breakthroughs) at the international level.
- Mountain lake researches (establishment of digital database, classification of pos-

sible remote threats, documentation of great mass gravity motions, etc.) in order to create a unified classification of mountainous lakes, to assess their breakthrough risk, and to develop proposals for minimizing risk of its impact on environment and population.

- To make inventory of geological objects and phenomena, potentially presenting remote geological threats to environment and the population (moraine dams, glacial lakes, mudslides, etc.) and to create a data base in accordance with GIS program.

- To study mountain lakes and to develop proposals for applying mountain lakes' potential for irrigation, portable water supply, health protection and mountain thematic tourism.

- To study interrelations between development dynamics of glaciation and geodynamic processes and formation and stability of mountain breakthrough risk lakes.

- To train staff and to exchange experience in investigation of breakthrough risk lakes and taking preventive actions.

- To develop unified methodological approaches for identifying and applying models of mountain lake breakthroughs, a breakthrough flow discharge and damage areas.

- To establish a Regional Mountain Center, covering a complex study of breakthrough risk lakes.

References:

1. I. T. Aitmatov, L A. Torgoev, Y. G. Alyoshin. Geodynamic factors of mudslide mass development on the Fergana ridge slopes. "Georisk", Tashkent-2003, p.12-14.
2. S. E. Airapetyan, E. K. Bykov. Morphology of Mertsbaher glacial lake and mechanism of its catastrophic breakthroughs. //"Some laws of Tien-Shan glaciation" Digest. – Frunze: Ilim, 1971, p. 75-84.
3. Kyrgyz SSR Atlas. V. I. Natural conditions and resources.- Moscow: USSRGYGK, 1987, 157 p.
4. A. Gostunskiy – Middle Asia hydrogeology, - 1996.
5. Kyrgyzstan mountains. Bishkek, "Technology", 2001, 319 p.
6. World mountains. Global priority. Edit, by B. Messerli, J. D. Ivez "Noosphere" Publishing House, M. 1999.450 p.
7. Report on human development in the Central Asia. UNDP, 20058. A. Rajabov, Major-General, Tajikistan Republic Prime Minister on extraordinary situations and civil defense. Report at the International Conference devoted to minimizing a risk of natural disasters in Chinese People's Republic held on 27-29 September, 2005.
8. I. V. Dergachova, D. S. Degtyarev. "Mudflows & breakthrough risk lakes of Uzbekistan" Information system/ "Georisk", Tashkent- 2003, p. 173-175
9. L. D. Dolgushin, G. B. Osipova. Pulsating glaciers. – LenPublishingHouse. Leningrad: Hydrometeoizdat, 1982.-192 p.
10. S. A. Yerohin. Glacial lakes as hydro-ecological objects and breakthrough risk factors thereof. // Water & Sustainable Development of Central Asia. "Soros-Kyrgyzstan" Fund, 2001. – p. 93-98.
11. S.A. Yerohin. The Petrov lake breakthrough risk. // The Issykkul lake hydrodynamics study with isotope methods application.- Bishkek: Him, 2006. – p.132-140.
12. V. T. Zufarov. Legislative basis of civil protection in Republic of Uzbekistan/"Georisk" Tashkent 2003, p. 49-54.
13. Y. A. Izrael, G. V. Gruza, V. M. Kattsov, V. R Meleshko. Global climate change. Role of anthropogenic impacts // Meteorology and hydrology. – Saint Petersburg, 2001. – #5. – p. 5-21.
14. N. R. Ischuk. Application of space images during relief geo-morphological mapping/Natural environment study with space technologies. Issue 2 – Dushanbe, 2005. p. 47-68.
15. L A. Karimov "Uzbekistan on the threshold of the 21st century: threats for security; conditions of progress and safety", Uzbekistan-1997.
16. V. A. Kuzmichonok. Mathematical-cartographic modeling of possible amendments of water resources and glaciation of Kyrgyzstan during climate change//Bulletin of Kyrgyz-Russian Slavic Institute.- Bishkek, 2003.-#6. - V.3. – p. 53-64.
17. International Conference materials – Application of geographic information systems and stimulation models for investigations and decision making in the Central Asia river basins-2004.
18. Monitoring, forecast and training to respond to possible activations of hazardous processes and phenomena on the territory of Kyrgyz Republic and areas adjacent to the Central Asia states- Beshkek: Technic. 2006,-618 p.
19. L. A. Molchanov. Middle Asia lakes. Tashkent. Middle-Asian State University, 1929.83 p.
20. National report environment protection and natural resources management for 20022004. UzRep National Nature Committee.
21. Our future climate // WMO, # 925. – Geneva, 2003. – 37 p.
22. A. M. Nikitin. Middle Asia lake morphometry and morphology //- SARNIGMI works, 1977, issue 50, p. 4-21.
23. A. M. Nikitin. "Middle Asia lakes". L, Hydrometeoizdat, 1987.
24. Tien-Shan lakes / A. V. Shnitnikov, Editor in charge. – Leningrad, 1980. – 232 p.
25. Tien-Shan glaciation / M. B. Dyurgerov (Russia) & Lyu Shaohai and SeZichu (China), Editors in charge.-Moscow, 1995. – 233 p.
26. Report on aero-visual survey of high-mountain and breakthrough risk lakes of Pskem, Oygaing, Shavursay and Koksy river basins. SANIGMI, 200.6
27. The first national correspondence of Kazakhstan Republic on the UNO Framework Convention on climate change. – Almaty, 1998.-73 p.

28. The first national correspondence of Uzbekistan Republic on the UNO Framework Convention on climate change. – Tashkent, 1999. – 112 p.

29. The first national correspondence of Kyrgyz Republic on the UNO Framework Convention on climate change. – Bishkek, 2002. – 92 p.

30. O.A. Podrezov. Mountain meteorology and climatology. – Bishkek: Publishing House of Kyrgyz-Russian Slavic University, 2000. – 269 p.

31. O. A. Podrezov, A. N. Dikikh., K. B. Bakirov. Changeability of Tien-Shan climatic conditions and glaciation within the last 100years//Bulletin Kyrgyz-Russian Slavic University – Bishkek, 2001. –#.3.-V.I. – p. 33-40.

32. Procedure for identification of zones of flood and mudflow damage by mountain lake breakthroughs on the territory of Kyrgyz Republic. SP KR 22_102:2001. – B.: 2001,-17p.

33. V. R Pushkarenko, A. M. Nikitin. Regional experience of research of dam status at the Middle Asia mountain lake and the nature of breakthrough mudflow formation. Mudslides and mudflows. Digest. Vol. 2..: GKNT International Project Center, 1984. – p. 17-32.

34. Problems of internal water ecosystems conservation in Central Asia and Southern Caucasus. 2006.

35. Report resume on climate change in Tajikistan. – Dushanbe, 2001. – 31 p.

36. V. N. Reyzvikh, A. M. Nikitin. On geographical distribution and standardization of Central Asia lakes. – TGMO works. // Digest, issue 3. Tashkent, 1968.

37. The USSR surface water resources. Hydrological knowledge. V.14. Middle Asia river basins.Issue.3. The Amudarya River basin. HydroMeteolzdat. 1967.

38. Environment state and natural resources management in Uzbekistan. Tashkent, 2003.

39. A. T. Turatbaev. Bostanlyk area mudslide risk assessment. "Georisk", Tashkent, 2003, p. 72-76.

40. Remote geological threats in the Southern-Western Pamirs, GBAO, Tajikistan. / Brief report made by Swiss Development & Cooperation Department (SDCD) for MES. RT J. Snhneider. M., Gmendel, 2005.

41 I. F. Uralov. Assessment of mudslide risk in Angren mining area /"Georisk", Tashkent, 2003, p. 67-70.

42. V. E. Chub. Climate change and its impact on natural resource potential of Republic of Uzbekistan. – Tashkent: Publishing House of Middle Asia Research Hydrometeorological Institute, 2000. – 252 pgs.

43. V. I. Schults. Middle Asia hydrography. // SAGU works, new series, issue 129, geographical sciences, Book 13, 1958.

44. "Hydrometeorology Agency" materials, Republic of Tajikistan:

USSR surface water resources. Catalogue of Kazakhstan and Middle Asia lakes studied with assessment of their mudflow risk. V.14. Tajikistan, Issue.3. G.A. Kernosov, S.Yavkin. Tajik SSR Hydrometeorological Agency Department. Dushanbe, 1976.

A.A. Yablokov. Assessment of state of glaciers, snow slides, mudflows and mountain lakes. 2006.

45. Materials of "Geologiyatochik" Geological Department of Republic of Tajikistan:

Results of reconnaissance hydrological survey of 35 lakes in South-Western and Central Tajikistan. "Geologiyatochik" Funds. 1964.

Preliminary assessment of breakthrough possibility at some logjam lakes in Tajik SSR according to works of 1967-1968. V.D. Fomenko, etc. "Geologiyatochik" Funds, 1970.

P A. Pogrebno, S. A. Shkalina. Results of reconnaissance hydrological survey of Ussoy logjam, the Sarez Lake sides and small lakes in the Gunt-Shakhdara rivers basins based on 1974-year works. Surveyor, "Geologiyatochik" Funds, 1975.

- V. D. Fomenko, A. P. Kostyuchenko, N. V. Kirnichyova. Results of reconnaissance hydrological survey of the Karalang, Shur-Kul, Gulikvsk, Kainar, Soviet, Garm, Chashma-and-Sangak, Iston, Yanur and Hazrati-Polima lakes, made in 1960. Report of Karatag Expedition Lake Group for 1960. "Geologiyatochik" Funds, 1961.

RENEWABLE ENERGY RESOURCES IN CENTRAL ASIA

Contents

Assessment Report on opportunities and prospects of using renewable energy sources in Central Asian countries has been prepared by the Working Group of experts from Republics of Uzbekistan, Tajikistan, Kazakhstan, Turkmenistan and Kyrgyz Republic, under the financial support of UNEP within the REAP Project.

The given Assessment report presents the situation of using traditional and renewable energy sources and works done for RES in Central Asian countries both in the region as a whole and on the national level.

During the preparation of the Assessment Report the materials were used, which were received from all interested ministries, departments and organizations located in Central Asia, activities of which are related to the usage of all types of energy.

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1. Introduction (Priority Rationale)

Rational use of natural resources and conservation of environment in good state are the foundation for sustainable condition of ecosystem. The growing use of traditional energy sources (oil, gas, coal), as the practice implies, considerably damages environment. In the process of energy development, according to the estimation of specialists, because of combustion of the fuel, 150 M.tn of ash, 100 M.tn of sulfur dioxide, 60 M.tn of nitrogen oxides, 300 M.tn carbon oxide, carbon dioxide and many other substances are emitted into the Earth's atmosphere. Analysis of energy production and qualitative composition of emissions showed that the active pollutants of the atmosphere are carbon dioxide (CO_2), methane (CH_4), ammonia (NH_3), hydrogen sulphide (H_2S), etc.

One of the tasks in the sphere of environment protection is prevention of ecosystem pollution, as far as possible, using environmentally friendly nonconventional renewable power sources: sun, wind, geothermal water, small watercourses, etc.

In conditions of current considerable price growth for the hydrocarbon fuel in the Central Asian countries and significant resource inputs for the centralized energy supply for the remote regions, the perspective value of decentralized energy supply of considerable amount of dispersed sites in CA countries using different types of RESs has become obvious. In this connection, the development of National Action Programs in certain countries as well as Subregional RES Development and Use Concept in CAR is of great necessity. Within these concepts it is necessary to develop measures to surmount existing barriers for RES development such as financial, technological, institutional, legal, personnel, etc.

The goal of the current Report is to estimate the potential and opportunities of non-traditional renewable power sources development in Central Asian region in order to reduce the impact of energy facilities using hydrocarbon fuel on environment due to the use of clean sources of energy production.

Assessment Report has been prepared under the Memorandum of Understanding between UNEP and the State Committee on Nature Protection of Uzbekistan in compliance with decisions adopted at the Session of Interstate Commission on Sustainable Development, which was held on March 2, 2006 in Ashkhabad (Turkmenistan), on emerging issues of renewable energy sources development in Central Asia.

Fig. 1. Solar photoelectric systems

2. Problem Status (Energy Resources and Power Engineering Development Condition)

Central Asian countries in general possess a wide and diversified energy resource basis though distributed non-uniformly around the territory of the region.

Along with the proven hydrocarbon reserves (oil, natural gas, condensate, coal) considerable water power potential is concentrated in the region, practicable for the development both from technical and economic points of view; there are also large uranium deposits. At the same time it is necessary to mention that in general the degree of investigation of the power engineering resource basis is supposed to be higher that can be explained by shortage of investment resources allocated for this purpose, particularly limited recently.

CAR countries, taking into consideration their different provision of power engineering and internal energy consumption with resources, have to solve the problem of strengthening energy supply in various ways, though these countries have many similar negative factors impacting its level.

2.1 Estimation of Current Energy Condition

One of the most important indicators for the estimation of energy supply of the countries of the region with this or that type of the fossil fuel is the ratio of resource potential and annual energy production (period of resource depletion). In accordance with the proven coal reserves, their period of depletion under the estimation as of the year 2000 comprises more than 600 years for the region (with the production of 668.0 M.tn), for oil – 65 years (with the production of 45.2 M.tn), for natural gas approximately 75 years (with the production of 88.4 bin.m^3).(1). Volume of implementation economically efficient part of water power potential by nowadays makes up a bit more than 10% that gives wide opportunities to satisfy the growing requirements of CA in electricity due to significantly cheap waterpower resources provided it won't be in conflict to the irrigational needs of the countries of the region.

Presented data are the evidence of the fact that there are prerequisites for supply of CAR with energy resources. However certain CA countries' provision with energy resource considerably differs *(Table 1)*. Condition of Kazakhstan in resources provision of all types is more preferable. Kyrgyzstan, Tajikistan possess significant water power potential and small opportunities in hydrocarbon fuels as the result of which the issues of heat supply of industry, cities, population are in critical situation. For their solution these countries have to import energy resources from Kazakhstan, Uzbekistan that is complicated because of the economic situation in Kyrgyzstan and Tajikistan.

Turkmenistan and Uzbekistan possess sufficient reserves of hydrocarbon resources for the mid-term prospects (20 – 30 years). Turkmenistan has insufficient possibilities in the sphere of hydroelectric potential. Possibilities of Kazakhstan and Uzbekistan in the sphere of hydroelectric potential are estimated to be medium.

During the last period of the transit economy in spite of the outlined rise of economy the general decay hasn't been overcome. In coal industry the coal production has reduces almost twofold. The major producers of coal are known to be Kazakhstan and Uzbekistan, and coal consumers are to be electric power stations and boiler-houses. In oil industry during the last years the growth of oil production has become perceptible, which amounted to more than 31.2%. 2/3 of the summary oil production volume accounts for Kazakhstan. Oil products consumption in the region has reduced by 43%. Indices of internal oil self-supply are as follows: in Kyrgyzstan – 0.3%, in Tajikistan – 0.073%. Kazakhstan, Turkmenistan and

Uzbekistan belong to the countries with sufficient oil self-supply. In gas industry the production falloff amounted to 20.5%. Activation of gas production happened to be in Kazakhstan, Turkmenistan and Uzbekistan. Uzbekistan produces the lion's share of gas, and in absolute indices has come out to the first place in the region. Decrease in gas consumption by 17.4% can be observed. In general, the region can be considered as gas abundant, but at the same time the production can be increased. In power industry the power production and consumption has reduced approximately by 28%. In spite this, Kazakhstan and Uzbekistan are to be the centers of power production. Basic resources for heat and power production are coal (in Kazakhstan) and gas (in Turkmenistan and Uzbekistan). The main consumers for heat and electric power are industry and population.

All-sufficiency of the country or region is defined by the ratio of the level of its annual production and energy resources consumption. According to the estimation of specialists [2; 3] during the past period this index on the average around CA amounted to 1.43, and in Turkmenistan – 2.33, however in Tajikistan this index totaled only 0.4.

Consideration of the situation on CA countries taken separately (inset 1) gives the foundation to emphasize that none of the CA countries has the absolute energy provision for the short-term perspective satisfying conditions of sustainable development because is called forth by the impact of destabilizing factors of economic, social and environmental origin.

For CA countries it is characteristic that integration processes in the sphere of power engineering were and will be of vital importance because of high power interdependency and complementarity existing for decades. They have the common energy space based on the joint electrical power system and the network of the main gas pipelines built in Soviet times, through which natural gas is delivered from: Turkmenistan, Uzbekistan to the southern part of Kazakhstan, Kyrgyzstan and Tajikistan.

With the gaining of sovereignty each of these states faced the necessity of independent solution of the problem of provision with energy resources, reliable and uninterrupted fuel and electricity supply.

Table 1. Resources Potential of Power Engineering of Central Asian Countries

Energy Resources	Kazakhstan		Kyrgyzstan		Tajikistan		Turkmenistan		Uzbekistan		Central Asian region	
	Years											
	1	2	1	2	1	2	1	2	1	2	1	2
Coal, bln.tn.	34,1	34,1	1,34	1,27	0,67	1,0	Insignificant	Insignificant	2,0	2,0	38,1	40,37
Oil, M.tn	2760	2760	11,5	10,2	5,4	10	7688	7688	81	81	14917,9	14921,2
Natural gas, bln. m³	1841	1841	6,54	6,2	9,2	10	20350	20350	2000	2000	26726,7	26727,9
Waterpower potential, m.kWh/year	27	27	52	99	317	317	2	2	15	15	413	460
Uranium, thous.tn	601	601	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant		83,7	684,7	684,7

a) For coal, oil and natural gas the volumes of proven reserves are given,
b) Economically efficient waterpower potential is presented
c) Uranium proven reserves are presented in accordance with the estimation of МИРЭС with production costs up to 130 USD/kg.

Shortage of financial resources for the development of fuel and energy complex as well as an excess of energy resources in a number of CA countries impels them to search sources of financing and possibility of modernization of energy resources through the exit to the international markets of energy carriers. In this connection the necessity is obvious to develop an energy transport infrastructure in certain CA countries.

The most important strategic task for the CA states is the attraction of wide investments into the development of new fuel fields, modernization of existing, building of new pipelines and maintenance of pipelines under operation in working conditions. Moreover, the most important issues of energy security requiring the top-priority solution are the joint efficient utilization of water power resources, water power complexes of international and national importance already created and having great potential for building.

During the year 2000 the total capacity of electric power stations of the region amounted to 41.86 M.kW. With this the share of thermoelectric power station (TPS) is 70.22%, and HPS – 29.78%, *(Table 2).*

Generating capacities of electric power stations of the region in general provides internal needs of economy and population in electrical energy.

It is important to emphasize the necessity of strengthening the parallel work of national energy systems within the incorporate CAR energy system. In 1999 leaders of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan signed the Agreement on establishment of the Incorporate Energy System of CA State. However the system does not work due to subjective reasons.

Table 2. Structure of Installed Capacities, M.kW.

Name	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan	Central Asian Region
Power stations of all types	18,81	3,688	4,413	4,05	11,583	41,864
Including: TPS	16,50	0,738	0,346	4,05	9,844	29,688
HPS	2,26	2,95	4,067	Insignificant	1,739	12,176

3. Indicators of Estimated Problem

During formation of indicators the whole complex of issues and problems should be covered related to the energy production and energy resources supply.

Indicators conform functionally and characterize types, conditions and results of utilization of renewable energy sources. For Central Asia, as is known, the following types of RES are characteristic: solar radiation, wind energy biotechnologies, hydrothermal energy, energy of small rivers.

According to the proposal of experts from Kyrgyzstan it is advisable to use indicators suggested by the UN Commission for Sustainable Development (CSD) as the main indicators of the state, use and impact of the energy sector on environment. The system of the key indicators of UN CSD includes:

- Annual consumption of energy per capita;
- Share of consumption of renewable energy resources;
- Intensity of energy utilization.

The first two indicators have been quite widely used in the international practice. The third indicator, according to the opinion of experts from Kyrgyzstan, should be replaced with indicator ***"Production energy output"*** or ***"GDP energy output"***, as intensity defines the process, but does not concretize the quantitative measurement of the process itself, in this case, efficiency of energy carriers utilization in the process of production of final output. Additionally it is possible to introduce the indicator ***"Share of renewable energy resources in GDP energy output"***..

It seems possible to use the following indicators.

- production (mining) of energy resources: coal, M.tn; gas condensate, M.tn; gas, bin m^3; uranium, thous.tn; used hydropotential, bln.kWh/year;
- electric power production (bln.kWh/year) using (coal, oil and gas condensate; gas;
- uranium; hydropotential);
- energy resources consumption (coal; oil and oil products, gas; water power);
- share of using organic fuel in GDP;
- share of using renewable energy sources (RES) in GDP;
- volume of received electric power (from using organic fuel in HPRTPS and; renewable energy sources, solar energy, wind energy; biotechnologies; hydrothermal sources, small rivers and canals;
- provision of the population with electric power from using renewable energy sources (solar energy and wind energy, biotechnologies, hydrothermal sources, small rivers and canals).

Fuel and energy complex (FEC) of ***Kyrgyz Republic*** *possesses approximately 2% of the total energy resources of Central Asia, including large reserves of coal, and about 30% of water and power resources of the region, of which currently only one tenth part has been developed.*

At present the structure of the fuel and energy balance of the republic is oriented towards the import of more than 50% energy carriers from the neighboring states. Self-sufficiency of the republic with oil products amounts to less than 30%. Analysis of possibilities of development of new oil and gas fields allows stating potential possibility to significantly increase oil and gas production and reducing dependence of the country on import. The country possesses significant water power resources. 5% of GDP and 12% of industrial production, 10% of revenues of the state budget account for its share. Developed electric power network provides the access to the electric power for 100% of the population.

Kazakhstan *possesses significant reserves of coal, oil and gas. At the same time, because of the geographical isolation of energy excessive and energy efficient regions of the country, because of the weak development of energy transport communications oil and gas from fields in the west of the country does not reach consumers of the densely populated south-east and industrial north. There are limitations in possibilities for exporting gas and oil to the contiguous CAR countries, Russia, China as well as other international markets of energy carriers.*

Power engineering of Kazakhstan is based very largely on coal. In conditions of sharp growth of energy carriers prices and low paying capacity of consumers of the republic, the main task for efficient use of energy in Kazakhstan are as follows:

- *Formation of common intrastate market of energy resources, the main suppliers of which would be domestic ones.*
- *Provision of the access for the Kazakhstan's producers of fuel and energy resources to international markets in close interaction with the neighboring states.*
- *Recommencement of economic relations and former forms of cooperation with CIS countries.*

The problem of energy supply for the needs of economy is the main problem for ***Tajikistan****. Coal and oil production is on the level of 0.02 M.tn, and gas – 0.04 bln. m^3. The country stakes on the use of rich water power resources and renewable energy sources, particularly small HPS.*

Turkmenistan *possesses significant energy resources potential sufficient not only for its own use. Turkmenistan possesses significant oil reserves, and occupies the second place in the region in gas production – produces more than 63 bln.m^3. Factors of constraint are insufficiency of energy transport infrastructure, the same as in other countries.*

Uzbekistan *occupies the first place in gas production – more than 55 bln.m^3 and the second place in coal, oil and gas condensate production. The priority in the republic is establishing of large oil and gas resources processing enterprises and facilities for fuel self-sufficiency, however this won't solve the problem of energy provision of all potential consumers located in the most remote regions. The main problems are – high energy output of economy, depreciation of equipment, weak energy transport capacity.*

4. National Strategies, Policies Implemented in the Countries

In conditions of essential growth of hydrocarbon fuel prices in CA countries and defining of technical-economic limits of centralized energy supply with significant resources consumption, the advantages of decentralized energy supply of substantial amount of disseminated objects in CA countries with the use of different types of RES has become obvious.

The carried out scientific and technical, and engineering-research works and created reserve allowed CA countries step-by-step using of separate types of RES.

The most efficacious works in all CA countries are being carried out in using water and power resources of medium and small watercourses through renovation of earlier constructed HPPs, construction and designing of HPPs of medium, small and micro-capacities on the earlier undeveloped rivers, as well as on irrigation constructions: water reservoirs, canals of irrigation and drinking-water purpose.

In ***Uzbekistan***, in compliance with the "Program of Small Hydro-Power Engineering" [8] implemented under the adopted in 1995 Decree of the Cabinet of Ministers of Republic of Uzbekistan, the first phase envisages construction of five medium and small quick-recouping HPPs with the total determined capacity of 422.8 MW and average long-term electric power output of 1 328.8 M.kWh/year. A number of HPPs, construction of which has been started already, will be put into operation till 2010.

In the second phase it is envisaged to construct 127 small HPP with the total determined capacity of 757.1 MW average long-term electric power output of 3306.2 M.kWh.The goals of the Program are to ensure the saving of natural gas, improvement of electric power supply of agriculture and water industry, improvement of environmental situation and solution of social issues in rural area.

Implementation of the Program is restrained because of insufficient financial resources, imperfection of existing legal basis in the field of power engineering, institutional barriers, lack of wide spectrum of incentive measures: reduced crediting and taxation, exemption from taxation and customs duties for imported equipment, accessories, special materials, etc.

Prospects of power engineering development in ***Kyrgyzstan*** are determined in accordance with the Program of Small Hydro-Power Engineering Development for 1999-2005 and posterior periods, which was developed in 1999. Currently, for the wide utilization the technically prepared are as follows:

- micro-HPP with the capacity of 1, 5,16, 22 kw – 10.8 M.kWh per year;

Fig. 2. MicroHPPTurbogenerator "Aquatron – 300"

- small HPP with the average determined capacity up to 5 MW – one plant each year with the average annual capacity up to 30 M.kWh of electric power,
- hot water supply produced from solar radiation on the basis of solar collectors manufactured in Republic with the annual capacity up to 5 M.kWh per year;
- biogas facilities with the capacity from 5 up to 250 m^3/day (summary annual productivity can amount 273 M.).

In ***Tajikistan*** in early 1990-s the Program for the power engineering development was adopted according to which in 1991 - 2005 there was stipulated commissioning of new facilities with the capacity of 22.4 thousand MW with the annual electric power production of 86.8 bin. kWh. During the last years small HPPs are built on the Bartang River, on the tributary of the Vang River, on Katochdara, Gurt, Ziddy Rivers and others, which are to promote electrification of settlements located in hard-to-reach mountainous areas.

Solar energy of CAR is used for different purposes. From 1995 systems of solar heat supply (SSHS) of seasonal and all-the-year-round function started to be used quite intensely. In the latter case they are used in combination with additional energy source – electrical boilers of small and big capacity, as well as with fuel heat sources.

In ***Uzbekistan*** SSHSs have been commissioned *[9]* with the total area of solar collectors of more than 50.0 thous.m^2 for hot water supply of domestic-sanitary and industrial purposes in facilities of different fields of economy.

Also solar-fuel boiler-houses within the heat supply systems have been implemented in 2 residential microdistricts of Tashkent, in which solar facilities of local production have been used as well as of European manufacturers.

Technology has been mastered and serial production of solar heat plants has been arranged by local manufacturers under the technology transferred by the Denmark Government within the UN Development Program based on the accessories purchased abroad. Manufacturing of equipment, development, designing, assembling, setting-up, commissioning and service maintaining of solar-electric module sources of heat supply of all-the-day-round function was arranged. Specialized enterprise "Kurilishgelio-Service Ltd." was established, providing a wide spectrum of works and services in the field of SSHS beginning from manufacturing of equipment along the whole chain of works and finishing with service maintenance.

A scientific and technological, material-science, systemic work complex is under implementation, aimed at the search of ways of improvement of SSHS consumer index and rise of their competitiveness in comparison with systems of hot water supply on traditional energy carriers.

Work is carried out in the field of building solar-heat power stations with thermodynamic cycle of transformation both with "central solar radiation receiver-transformer» and distributional cylindrical parabolic concentrating transformers urged to provide electric power production in industrial scales (several M.kWh per year) with minimum consumption of natural gas in fuel part of the station and with maximum utilization of solar radiation.

Utilization of geothermal energy has been started for heat supply in Uzbekistan; building of geothermal power stations is quite possible based on perspective technologies with low-boiling energy carriers.

Insufficiency of organic fuel in Kyrgyzstan and Tajikistan has currently already resulted in deficiency of heat and energy supply or to the breakage of their energy security.

In Uzbekistan the risk of breach of adequate energy provision for the mid-term perspective remains because of accelerated natural gas production used as a main type of fuel during electric power and heat energy production as well as export product, and because of insufficiency of water and power resources (lack of potential for construction of large economy-type HPPs), which could be the substitute for gas utilization.

A number of local regions in Kazakhstan, Tajikistan and other CA countries, remote from centralized state systems of gas and electric power supply, currently have suffered from lack of fuel supply, which resulted in the shortage of heat supply. In some remote regions and settlements of CA countries there is a deficiency in electric power supply. Thus, we can state that energy security of CA countries is not absolute.

These factors as well as the worsening environmental situation, unfavorable social situation developed in a number of regions of all CA countries, which is characterized by inconsistency between life conditions of the population and modern requirements; downswing in production, including the downswing because of the shortage of energy supply and because of other reasons, induced CA countries to use a number of types of renewable energy sources.

Geographic situation, natural and climatic conditions and big dimensions of the CA countries' territories create conditions for the power engineering development due to the utilization of a plenty types of RES, enough for meeting internal needs and energy security ensuring for the long-term perspective. One of the most important economy branches of almost all Central Asian countries is the outrun livestock-breeding on the natural pastures, where million herds of sheep and cattle are grazed. There are practically everywhere water resources with different mineralization level, however after the appropriate treating or desalting they can be used for development of pasture livestock-breeding. The difficulty here consists in the availability of energy sources. For these cases the optimum alternative is the utilization of solar or wind plants, which can provide with the energy supply for lifting and pumping water, and in the case of mineralized water – their desalting. Besides, in the nearest 20 years the cost of hydrocarbons will reach the level, when its combustion for production of energy will become unreasonable.

Available estimation data on RES resources potential in CA countries is presented in *Table 3*.

It should be specifically emphasized that RES resources potential, in particular energy of solar radiation coming during the whole year to the territory of CA countries, iteratively exceed consumed volumes of energy resources. Moreover, availability of significant amounts of geothermal energy in Uzbekistan, Turkmenistan, Kazakhstan and possibilities for gaining biomass of vegetation origin in big amounts and on vast territories as well as low knowledge about production of water and energy resources on medium and small water courses create good preconditions for wide-scale RES involvement into the fuel and energy balance of all CA countries for the purpose of ensuring sustainable environmentally safe development of power engineering.

The work in direct transformation of solar radiation into electric energy is widely carried out in ***Uzbekistan.*** Technologies for producing silicon of "solar" quality on the basis of big reserves of silicon-inclusive crude ore, quartzites are worked out for further production of solar semiconductor converters (elements, modules) for the purpose of building photoelectric stations of different levels of capacity and function. Industrial manufacturing of solar modules based on amorphous silicon has started. Preliminary feasibility calculations for substantiation of the possibility of constructing solar electric power stations in CA countries with the capacity up to 200 MW were developed. In compliance with these calculations the expediency of establishing of 16 solar electric

Table 3. Resource Potential of Renewable Energy Sources of CA Countries

Energy resources	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Solar radiation, bln.tn.cond.t./ year	500,0	41,0	30,0	102,0	95,0
Water power resources of medium and small watercourses, bln.kWh/year	4,8	8,0	25	insufficient	21,2
Geothermal resources	Data n/a	613M. Gj'/year	Data n/a	Data n/a	503 bln.tn.y.т
Wind flows, bln.kWh/year	1000,0	Data n/a	–ıı–	5,6 bln.tn./year	25,85
Biomass, bln.tn./years	15,0	–ıı–	–ıı–	insufficient	3,3

power stations with the total capacity of 506 MW realized under different technologies was shown for Uzbekistan in the first stage. Also, combined solar photoelectric facilities for domestic purpose of micro-capacity level (less than 1 kW) are manufactured and placed in operation in Uzbekistan based on solar modules produced on the basis of monoc-rystal and amorphous silicon elements for individual utilization. Demonstration combined solar-wind system of power supply for objects located in out-of-the-way areas has been created, which proved that decentralization of power supply of remote sites is to be perspective based on the combined utilization of several types of energy (solar, wind, electrochemical).

Fig. 3. Solar power plants

Concerning the accessibility of energy from renewable sources, particular from the sun, research and development works are executed in Uzbekistan on practical utilization of solar energy, including:

- development of solar water heating collectors of a new type for the systems of hot water supply;
- development of autonomous and combined solar-fuel systems of heat supply of the all-year-round function;
- development of photoelectric elements from monocrystal silicon with the efficacy in producing electric power in the amount of 12-14% and utilization of polycrystalline silicon with the efficacy of 10-12% and organization of their production at the capacity level of 50-200 Wt;
- thermodynamic conversion of solar energy into electric one with the help of solar radiation concentrators;
- development combined wind-solar systems for combined utilization of energies of wind and solar radiation;
- development electric power station of solar furnace with the heat capacity of 1000 kW of radiant flux in the focus (temperature ~ 3200° C.), equipped with the focusing device consisting of a system of 236 mirrors with automatic monitoring of the flux position and designed for obtaining extremely pure metals;
- development passive systems of solar heating of low-rise residential buildings with the high heat efficacy.

According to results of these works there were manufactured and put into experimental exploitation:

- solar double-circuit water heating facilities of the all-year-round function with flat solar collectors;

- solar add-on devices for warming initial water in heating boiler houses for heat supply of microdistricts (of a settlement);
- helio facilities for treating fecal and industrial sewage with the capacity of 50 mVday and treatment of biomass of algae into fodders;
- solar photoelectric stations, elements, modules for energy supply of dispersed and remote from power lines low-capacity consumers;
- combined solar-wind system of power supply of high-capacity (10 kW and more) consumers;
- passive systems of solar heating with flat reflector and accumulator of solar energy collector.

Within the State scientific and technical programs and innovation projects till 2010 it is scheduled to conduct applied investigations in the following directions:

1. To develop projects of combined utilization of renewable energy sources, including solar, wind and microHPSs;
2. To organize on the local production basis the manufacturing of photoelectric elements and modules;
3. To develop highly effective flat heat collectors as well as heat facilities for getting low-potential heat for housing and communal sector and to organize their manufacturing at the industrial enterprises;
4. To develop programs of decentralized electrification of remote settlements based on utilization of renewable energy sources;
5. To develop and introduce into practice of communal heat and power engineering decentralized solar-fuel heat supply systems.

Works in this direction are implemented in the Physical and Engineering Institute, in the Institute of Energy and Automation of AS of Republic of Uzbekistan, in the Center of Scientific and Technical and Marketing Investigations on compound solar-wind system. Agency of Communications and Information of Uzbekistan have started production of solar panels for converting of solar energy into electric one, as well as solar collectors for water heating. Pre-production models have been produced and tested in SC "Foton", EEC "Geliokurilishservis"as well as in Physical and Engineering Institute of SPA "Physika-Solntze" of AS of Republic of Uzbekistan.

Analogous situation in utilization of solar energy is in other CA countries *[10]*. The Center of Problems of RES Utilization of Kyrgyzstan in 1998 developed "Concept of Renewable Energy Sources Development in Kyrgyz Republic till 2005". It is supposed in the perspective to establish facilities for producing electric power on photoelectric converters in the capacity of 2-3 MW with production of 5 – 8 M.kWh per year; respectively at micro HPS 2 – 2.5 MW and production of 9 – 11 M.kWh per year; wind-electric facilities 0.15 – 0.13 MW and production of 1 – 1.2 M.kWh per year. Manufacturing of solar photoelectric elements, modules and complexes has been developed; and on their basis – solar collectors and hot water supply systems. On request they are manufactured and systems of energy supply based on RES are put into operation.

CA countries possess possibilities for developing wind power engineering in certain regions. The Government of ***Republic of Kazakhstan*** approved in 1999 the Plan of Power Engineering Development till 2030. By this time it is necessary to build 7 RESs with the capacity of 520 MW with the annual electric power production of about 1.8 – 2 bin. kWh. Investments into the RESs construction will amount to about 500 million USD. The Government of Republic of Kazakhstan UN Development Program in 2004 started a joint project on development of wind power engineering "Kazakhstan – Initiative of Development of Wind Power Engineering Markets" meant for 3 years, and envisages assistance to the Government in construction of the first wind electric power station with the capacity of 5 MW in the south-east of the republic. More than 2.5 million USD was allocated by the Global Environmental Facility for the implementation of the project. Input of private investors will amount to 4 million USD. The Ministry of Energy and Mineral Resources of RK will be an executive agency for the project.

In ***Kyrgyzstan*** wind and energy resources, only in surface layer up to 100 m, is estimated to be of 2 bin MWh per year. Construction of wind power stations in a number of regions in Uzbekistan were revealed to be perspective, including Ustyurt plateau with the capacity of more than 10 - 20 MW and other places.

Development of power engineering is promising on the basis of using geothermal water in the foothill zones and valleys, for instance, using geothermal energy for heat supply in Issyk-Kul and other regions of Kyrgyzstan.

For small HPS in Kyrgyzstan – the summary hydro power potential of examined 172 small rivers and watercourses with water consumption from 0.5 up to 50 m\sec exceeds 80 bln kWh per year, of them the technically acceptable to the development hydro power potential amounts to 5 – 8 bln kWh per year, of which only 3% is used. For the period till 2010 it is supposed to realize technical reequipment and rehabilitation of conservated small HPS, as well as to construct in different regions of republic new small HPSs. Energy tariff growth, the efficiency of small HPS's functioning outlined for development, and payback of investments into this segment of power engineering will stimulate attraction of domestic and foreign investors.

In connection with the territory, all examined small rivers are grouped in basins confined to rivers Chu, Talas, Naryn, Sary-Zhas, Karadarya, Syrdarya and basin of the Issyk-Kul Lake. The possible peculiarities should be taken into consideration, which can occur during building of small HPSs on the transboundary watercourses.

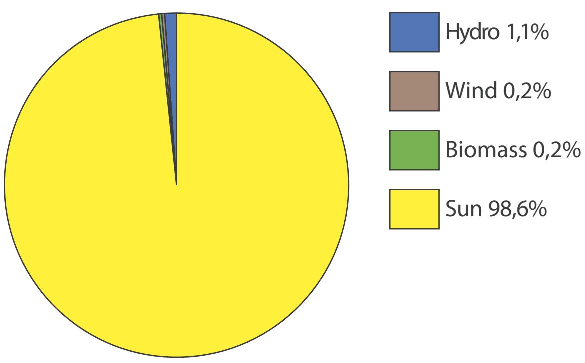

Fig. 4. RES Potential in Uzbekistan *[9]*

In ***Kazakhstan***, in Semirechye (Almaty Oblast) construction and renovation of 25 small HPS have been started. PC "KazNIIenergetika", Almaty, has assembled an electric power station of 500 kW in settlement Fabrichny of Almaty Oblast, an experimental HPSs of 130 kW (Medeo) on the water supply pipeline, 270 kW on "Vodokanal" in Almaty, stations are built in Southern Kazakhstan. Kazakhstan engineers and scientists currently have developed new module model of unmanned micro-HPS, for which preliminary patents have been received, pre-production model was produced and tests were conducted.

In connection with the energy tariffs growth, the efficiency of small HPS's functioning outlined for development, and payback of investments into this segment of power engineering will stimulate attraction of domestic and foreign investors.

Taking into consideration similarity of problems, which are to be resolved with the help of small hydro power engineering, it seems expedient to develop close coordination and cooperation between CA countries.

There are prospects in bioenergetics development. For instance, in Kyrgyz Republic *[11]* as a result of treatment of biomass, constituting livestock-breeding waste products (with the annual capacity of 5.5 M.tn), vegetation and other materials of organic origin, it is possible to gain more than 300 $M.m^3$ of combustible biogas per year. Biogas technologies are widely used in villages for the purpose of producing high-quality organic fertilizer, which ensures growing of environmentally clean products in contrast to the chemical fertilizers. There is a possibility to produce methane gas to be used instead of import natural gas. Four plants have been already functioning in rural area with the reactor capacity of 50-250 m^3 and a complex in village Petrovka of Sokuluksky region, which provides the Association "Fremer" with high-quality fertilizer, and due to methane – with electric and heat power.

In 2006 in Western Kazakhstan the unique biotechnological project was implemented: the plant for manufacturing of ethanol production – complex"Biokhim".

The project is a classical example of the cluster development: deep processing of grains and receiving of the final product – bioethanol. The plant will use the whole raw material including wastes.

In this connection the elaboration of the RES development concepts is necessary in CA countries for the period of 2020-2030, and on their basis – the National Action Programs of certain countries, as well as Subregional Concept of RES development and utilization in CAR.

Within the concepts the elaboration of measures is necessary for overcoming the existing barriers in the RES development: financial, technological, institutional, legislative, personnel, etc.

5. Needs Assessment in Problem Solution

Necessity of involvement of renewable energy sources into the energy balance of Central Asian states is based on a number of factors, the most essential of which are the following:

1. Maintenance of energy independence for the long-term perspective.
2. Energy supply of the further development of economy and increase of the welfare of rural population.

Fig. 5. Wind Facilities for RES

3. Provision of decrease of the man-caused impact on environment.
4. Ensuring of economy development of the states within "Sustainable Development".

As is known, maintenance of energy independence is the most important task of all CA states. As it was mentioned earlier, power engineering development in Kazakhstan, Turkmenistan and Uzbekistan is based on oil and gas resources, which, however, in foreseeable future will be more difficult of access, and growing cost will nor allow solving the set tasks in perspective. In Kyrgyzstan and Tajikistan the priorities of the power engineering development are based on the use of water and energy resources, however, the scantiness of existing and growing scarcity of water resources in the Aral Sea basin with make obstacles for the power engineering development.

An important factor for further development of economy and improvement of the welfare of the CA population consists in the energy supply of the rural population, residences of which are dispersed on the vast territory and in huge distances from cities. This stipulates a big amount of dispersed energy consumers, which are not provided with reliable energy sources. In many regions of CA states there are problems with the quality and quantity of electric power and natural gas supplied to the final consumer. There are remote regions, where there is no still centralized energy supply. In current conditions, when construction of 1 km of the power line costs 15,000 USD, energy supply of the remote regions and dispersed rural settlements, where the distance between houses is several kilometers, through the centralized line is practically unreal.

Decrease of man-caused impact on environment is the task of current importance for the states of Central Asia. Particularly this adversely affects the greenhouse gases emissions. According to the data of the Institute of World's Resources (data of 2003), the total amount of CO2 emissions in Republic of Uzbekistan constitutes 121.0 thous.tn per year, and occupies the second place after Kazakhstan (123685.6 thous.tn) in whole in Central Asia. At the same time, more than 80% (according to the data of Hydrometeorology Center of Uzbekistan) of emissions falls to the share of the energy sector.

As it is seen, the damage caused to the atmosphere is significant, not to mention about economic damage of payment environmental tax and fines. Therefore, the necessity of wide involvement of renewable energy sources into the energy balance, which are in parallel environmentally appropriate, is dictated also from the point of view of reducing the man-caused impact of environment.

Special attention should be paid to the necessity of meeting conditions of providing development to the economy of the states within sustainable development programs that is the basis for the world's development tendencies in compliance with the goals proclaimed on the Summit in Johannesburg (SAR) and seconded by all states of the world. As is known, the principle of "sustainable development" is satisfaction of needs in natural resources of the current generation, not affecting and not infringing interests of the future generations.

Successes in development of oil and gas industry in the mid 20th century – intensive commissioning of oil-and-gas and gas-condensate fields with small expenditures stipulated the growing role in oil and natural gas consumption in the total balance of energy resources consumption. However as the practice shows, intensive exploitation of earth and growing consumption of hydrocarbon resources results in depletion of nonrenewable natural resources that infringes principles of sustainable development.

Therefore, for the energy supply of further economic development of CA states and improvement of the welfare of the rural population the wide utilization of renewable energy sources being at the same time the local and decentralized source of energy. Renewable energy sources development will make a significant input in the maintenance of the fuel and energy balance and in programs of environment protection. According to the preliminary estimations of specialists, intensive renewable energy sources development on the whole territory of CA will allow to increase potential of the fuel and energy resources up to 20%.

6. Plan of Measures for the Nearest Outlook

Plan of measures for the nearest perspective is aimed at implementing work in compliance with the Assessment Report. In accordance with the plan it is supposed to carry out investigations, detailed analysis of the state and conditions of development of possibilities to utilize renewable energy sources and estimation of the input of producing energy from RES into the balance of energy production and consumption in CA countries as well as to establish the regional RES center and network in CA. the Plan of measures is given in *Table 4*.

7. Sequential Steps for Implementation of the Proposed Plan

For the development of RES utilization in Central Asia the consistency of fulfilling tasks, according to our opinion, is to consist in the following.

1) Study of potential and development of the concept of using RES along with determination of indicators for utilization of the whole potential of energy resources, including renewable energy sources.

The concept will be submitted for consideration to all concerned ministries in Central Asian countries, and then considered and approved by Governments of the states.

Fig. 6. Biogas Facility for Combustible Methane Production

2) Development of recommendations on technologies of using RES taking into consideration peculiarities of natural and climate conditions in each of the CA countries.

After the concept approval the analysis and estimation of technologies of RES utilization are conducted. Because of the difference in natural and climate conditions in the region the estimation of using technologies is made for each of the countries.

3). Elaboration of draft development program of RES utilization

For the practical realization of mechanisms of RES utilization it is necessary to elaborate the development program with substantiated amounts, priority trends, cost, possibilities of financing by CA countries and aid of international donors.

4) Development of the structure of conditions of the regional RES network interaction and regulations of national and regional centers.

Based on the concept and the development program of RES utilization there will be established the regional RES network with national programs. With this purpose it will be necessary to develop regulations and mechanisms of interaction. The established regional network will be aimed at implementation of projects for RES utilization in accordance with the project proposals presented in *Table 5*.

Table 4. Plan of Measures (draft) for Establishment of Subregional Network and Activation of Activities in Utilization of Renewable Energy Sources in Central Asia

Measures	Activity	Delivery Date	Budget (US Dollars)
Development and concluding an Agreement with UNEP	Formation of the text of Agreement, work budget, and schedule of their fulfillment, discussions with CA countries and UNEP.	Year 2007, January – February.	
Development of tasks for estimation studies for leading experts, institutes	Detailed tasks are to be developed with indication of objectives, trends and stages of realization on estimation of utilization, parameters of RESs and other issues necessary for the concept development.	Year 2007, February.	500
Development of the concept of utilization of renewable energy sources: • figure priorities for Central Asia; • determine mechanisms of the work coordination by CA regions in the given field; • develop conceptual trends.	• The gained experience in scientific elaborations and practical use of technology of renewable energy sources utilization; • Determination of the energy and economic parameters of RES facilities in conditions of Central Asia; • Priority trends in RES development are to be determined for each of the CA countries; • Principles and mechanisms of interaction and work coordination by regions; • Conceptual trends in activities for RES development are to be worked out.	Year 2007, March – April	15 000
Holding of the Regional workshop for discussing the concept.	Leading specialists will be invited to the Workshop for determining dimensions, trends, stages and other issues related to developing activities on RES utilization.	Year 2007, April or May	4 000
Formation of indicators of utilizing renewable energy sources.	On the basis of activity estimation (scenarios) on RES utilization and characteristics of final results the indicators are to be determined.	Year 2007, May – June	2 500
Recommendation development on technologies for utilizing RES	While developing recommendations the substantiation of each type of RESs should be submitted.	July, 2007.	1 000
Development of a draft program for RES utilizing development, regulations of the national and regional network centers for RES.	Reliable and real for implementation types of RES should be entered into the program taking into consideration possibilities of the countries, and based on the program to develop regulations for centers.	August – October, 2007	10 000
Holding of the Regional workshop on the program	On the Workshop the program and regulations will be discussed and then amendments to these documents will be entered.	October, 2007	4 000
Consideration of results of the project at the ICSD meeting.	Presentation and consideration of recommended actions and programs.	November, 2007	5 000
Submission of materials to the governments of CA countries and concerned ministries and departments	Submission and discussion of documents to the concerned ministries and Governments of the CA countries.	November – December, 2007	
Total			**42 000**

8. Efficacy Assessment

8.1. Problems of Impact of Traditional Power Engineering on Environment and Ecology Condition

Intensive development of oil producing industries resulted in the fact that the industries dangerous for environment such as fuel, metallurgic, mining industries form the foundation of the modern economy of Central Asian states. And as a result – there are significant pressures of environment. Development of fields is the cause of damage and contamination of environment. The main sources of contamination are oil and drilling cuttings, waste water, hydrocarbons, nitrogen and sulfur oxides, hydrogen sulphide and gas condensate. One of the main environmental problems of oil fields of Central Asian countries is the problem of associated gas utilization during oil production. So, only in Kazakhstan at present more than 800 M.m^3 per year of associated oil gas is burnt in flares.

In Turkmenistan in 1990s during of the 20th century running of gas and oil and gas-condensate fields up to 1 bin cubic meters of gas was emitted.

Soil and ground pollution occurs through oil leakages, oil-field and shaft water discharges, unregulated machinery and transport traffic. So, in Western Kazakhstan the total area occupied by oil contaminations, according to the most minimum estimations, is about 200 thousand ha, and the area of radioactive contamination with the dose rate of more than 100 mcR/hour is more than 600 ha.

Oil refineries account for considerable share of atmosphere pollution. Sources if emissions into the atmosphere in these enterprises are oil refining plants, hydrofining plants, kerosene sweetening plants.

Of the total amount of pollutants from enterprises of oil and gas industry the share of hydrocarbons comes to 50%.

Specific character of oil and gas producing industry consists in the fact that its impact on environment is distributed along the whole technological chain – from exploring till final consumption. On all stages of fields' development and running the industry conducts geochemical contamination.

Leakages from gas pipeline networks and underground gasholders shouldn't be underestimated. Data of the state monitoring of emission sources in Uzbekistan implemented by territorial nature protection authorities show that during five years the systematic excess of norms of maximum permissible emissions (MPE) can be observed for sulfur dioxide (1.2 – 4.4 times), nitrogen oxide (1.5 – 1.9 times), sulfur dioxide (1.4 – 4.08 times).

The main input into pollutants emissions in Central Asia falls to the share of heat and power engineering in comparison with other stationary sources (for instance, in Uzbekistan it amounts to 31.3% *(Table 6)*, and transport.

TPS and HPP are located, as a rule, either in cities, residential areas or in immediate proximity to them. Places of their location are characterized with the increased level of air pollution with nitrogen oxides, sulfur dioxide and solid substances (cities of Tashkent, Navoee, Fergana). The main part of installed plants have been in operation for more than 25 years already, fuel use efficacy is extremely low and amounts to 33 up to 35%.

During fuel combustion in boilers of TSP along with emissions of pollutants (solid dust particles, sulfur dioxide, nitrogen oxides, carbon oxide, vanadium pentaoxide and benzpyrene) about 50% of carbon dioxide is emitted to the atmosphere, which creates a greenhouse effect. Amount of carbon dioxide emissions depends on carbon consumption and contents in the work mass of combusted fuels.

Other emissions – sulfur and nitrogen oxides turn into sulfuric and nitric acids and come back to the earth with snow or in the form of acidic rains. Increased acidity of water results in decrease of soil fertility, reduction of fish reserves and forests drying, damage of building structures and buildings. Toxic heavy metals cadmium, mercury, lead are dissolved by acids and get into drinking water and agricultural products.

For mountainous ecosystems the growing use of arboreal plantations (trees and bushes) and vegetation for covering the requirements because of the lack of energy resources is of great importance. According to estimations of specialists from Kyrgyzstan and Tajikistan, organic fuel famine, difficulties in its delivery to mountainous areas of Tajikistan, consistent growth of electric power prices, lack of electricity in many remote from main power lines places, force citizens of mountainous areas to use wood as fuel. This results in extermination of impoverished forest massifs, area of which has already reduced 5-10 times and in some places forests are completely eliminated. Bleakness of mountainous slopes leads to the increase of mud flows, soil erosion on slopes and finally to desertification, and actually causes "double» greenhouse effect. These processes result in changes in environment of mountainous region, destruction of its flora and fauna. In short, social-economic conditions force people to destruct mountainous landscape, which has been formed during centuries.

Thus, in Central Asia along with the growth of economy of the states, production and consumption of organic resources – coal, oil and gas – will grow, too. As the practice shows, the given resources cost very much for the economic activities of the states that is testified to by significant amount of non-payment for their use as well as pollution of environment, and consequently impacts the health and social conditions of the population's life. This situation is particularly important for countries of the Aral Sea basin in connection with the existing environmental crisis. Main zones of oil, gas condensate and gas production are concentrated in the given region and adjacent to it – zone of the Caspian Sea (Kazakhstan, Turkmenistan and Uzbekistan). For Kyrgyzstan and Tajikistan the actual lack of resources under consideration and accordingly, low provision with fuel and energy resources of the given type is very typical.

Environmental problems related to the fuel and energy complex become evident in three levels – local (air pollution in residential areas), regional (acid precipitation) and global (greenhouse gases). This should be taken into consideration during development of the sector development strategy, particularly in nowadays conditions of serious attention of the international community to the problem of potential global climate warming and coordination of effort for its prevention.

These factors stipulate for urgent need in searching and developing technologies for renewable energy sources usage.

8.2 Environmental, social and economic prerequisites for acceleration of renewable energy sources utilization

Expert estimation of specialists shows the principle technical possibility, social and economic preconditions for meeting requirements of the Central Asian regions in primary energy carriers with complex solution of environmental and social problems due to the high-scale use of renewable energy source resources and gradual reduction of the share of hydrocarbon resources usage as a fuel in production of heat and electric power, in manufacturing of a number of industrial and agricultural products.

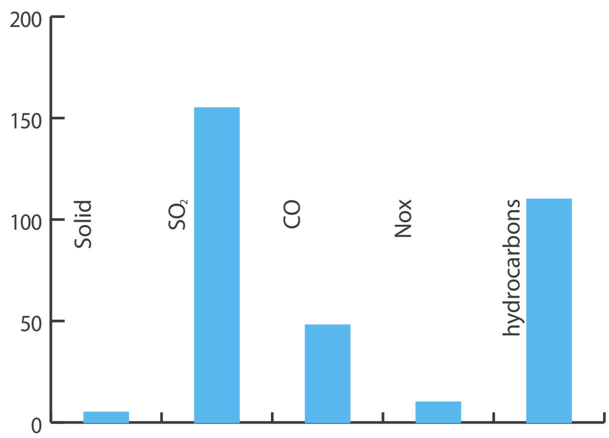

Fig. 7. Air Pollution by Oil and Gas Complex

Table 5. Regional Project Proposals on Utilization of Renewable Energy Sources

Name of the Project	Participating Countries	Goal of the Project	Planned Measures	Anticipated Results	Budget in US Dollars
1	2	3	4	5	6
Non-waste biotechnological complex based on renewable energy sources	Turkmenistan Kazakhstan Kyrgyzstan Tajikistan Uzbekistan	1. Development of a complex of measures for utilizing renewable energy sources in agro-industrial complex based on non-waste technology 2. Development of a project and implementation of non-waste biotechnological complex in CAR countries	1. Study and estimation of potential on biotechnologies in agriculture, industry and community sector. 2. Conducting of joint scientific and research works in the field of biotechnologies and receiving energy on their basis. 3. Development and testing of pilot projects on biotechnologies for receiving energy and their use in economic complex. 4. Improvement and harmonization of legislative basis on air protection. 5. Estimation of efficiency of biotechnologies utilization and development of recommendations.	Biotechnological complexes are to be established, in which technologies will be developed for using the livestock-breeding and agricultural-production waste products for energy receiving and using it in the industry	**1 500 000**
Energy and water supply of the CAR rural population based on renewable energy sources	Kazakhstan Kyrgyzstan Tajikistan Turkmenistan Uzbekistan	1. Development of a complex of measures for utilizing renewable energy sources in agro-industrial complex based on non-waste technology 2. Development of a project and implementation of non-waste biotech- nological complex in CAR countries	1. Determination of the energy RES potential. 2. Development of technological schemes taking into consideration climate and water resources. 3. Testing of certain types of equipment. 4. Development and testing of pilot systems of energy and water supply based on RESs. 5. Testing of pilot systems of energy and water supply based on RESs. 6. Environmental and economic estimation of efficacy, recommendations.	Technologies for using different types of RESs have been developed for promotion of energy and water supply of the CAR rural population located at the remote distance from central regions.	**250 000**
Development, creation of environmentally safe combined solar photoelectric complexes of energy supply, water lifting and water purification.	Kazakhstan Kyrgyzstan Tajikistan Turkmenistan Uzbekistan	Creation of environmentally safe systems of energy and water supply based on the combined solar photoelectric installations.	Gathering and processing of initial data and development of technical requirements	Pilot samples of environmentally safe systems of energy and water supply based on the combined solar photoelectric installations and wind-electric installations in the region	**340 000**

Name of the Project	Participating Countries	Goal of the Project	Planned Measures	Anticipated Results	Budget in US Dollars
1	2	3	4	5	6
Development of domestic solar desalterof high productivity	Uzbekistan	Development of domestic solar desalter of high productivity and final adjustment to be serially produced.	1. Development and manufacturing of the pilot sample of desalter and conducting of full-scale testing, including field ones. 2. Taking chemical and biological analyses of desalting water. 3. Development of technical and design documentation for desalter for the further industrial manufacturing. 4. Technology development for serial production of desalters from materials and accessories available in Uzbekistan.	Development of prerequisites and conditions allowing to start production of desalters on the territory of Uzbekistan	**100 000**
Development of National concepts of using of renewable energy sources by the example of Uzbekistan	Kazakhstan Kyrgyzstan Tajikistan Turkmenistan Uzbekistan	Development of concepts of using of renewable energy sources and estimation of ecological and social effect with the development of scenarios and action plan.	1. Concepts analysis of industries' development of fuel and energy complex for the period 2010-2020. 2. Forecast of ecological situation by regions of Uzbekistan. 3. Information updating on resources of different RESs by regions. 4. Substantiation of the concept of RES usage in Uzbekistan for the period 2010-2020.	Forecast estimation of ecological situation in Uzbekistan for the period 2010-2020.	**120 000**
Establishment of the RES center and regional network for using renewable energy sources.	Kazakhstan Kyrgyzstan Tajikistan Turkmenistan Uzbekistan	Identification and usage of potential of renewable energy sources in Central Asia.	1. Development of a concept of the regional network and RES center. 2. Development of a regulation on the regional network activities and RES center (RESRC). 3. Development of a program of RESRC activity. 4. Registration of RESRC in the state registers of CA countries. 5. Organization of the office and equipping of the center and departments.	Arrangement of practical activity of the regional network and work coordination for using of renewable energy sources.	**1 300 000**
Environmentally safe system of energy saving for rural settlements by the example of small HPPs on the main irrigation canals of Samarkand Oblast of Uzbekistan.	Kazakhstan Kyrgyzstan Tajikistan Uzbekistan	Creation of environmentally safe system of energy saving for rural settlements based on the usage of hydroelectric potential of the main irrigation canals.	1. Technical and economic calculations of systems of power and heat supply. 2. Development of schemes of power and heat supply on the main irrigation canals. 3. Development of the instruction for power and heat supply of rural settlements using small HPR.	1. Improvement of power and heat supply of rural settlements. 2. Fuel savings and reduction of environment pollution. 3. Establishment of new working places.	**800 000**
Utilization of renewable energy sources (RES)	Tajikistan (Pilot project and can be replicated in all CA countries)	Popularization of clean technologies of energy supply, improvement of conditions of life for mountain population	1. Cadastre of renewable energy sources (sun, wind, biomass, hydrothermal water). 2. Development and manufacturing of solar photoelectric power stations, water heaters, dryers, etc., wind-energy and biogasification plants 3. Introduction of plants in chosen regions of the countries.	1. Plants (solar, wind and biogas). 2. Establishment of a center of clean power engineer ing. 3. Exchange of traditional methods of energy production.	**750 000 (for each country)**

The doubtless advantages of the RES resources are their environmental safety, availability of a number of their types, first of all solar energy on the whole territory, and wind, geothermal, hydraulic energy and biomass energy in those regions, where there are difficulties in energy supply from the traditional centralized supply systems with natural gas, oil products, coal, electric and heat power.

For many regions of Central Asia the socio-economic preconditions are the priority, particularly in the desert and mountainous areas. So, for instance, according to the conclusions of Kyrgyz experts, of 5 million Kyrgyzstan citizens more than 2 million are poor people, and more than 50 thousand are extremely poor with the annual income not more 7 USD per capita. The main sources of energy for this group of the population are electric power and biomass of arboreal vegetation and livestock-breeding waste (pressed dung). The situation is getting worse because of the remoteness and high-mountain location of the residence territory. The most available sources of energy are trees felling of which has become of depredatory dimensions. Depredation of arboreal vegetation becomes incommensurable with the volumes of forest restoration. In such situation the renewable power engineering, mainly solar, biomasses and micro HPS with the targeted aid of the Government and other investors in order to create initial capital for construction or purchasing of any RES, stipulates civilized exit from the existing tangle of problems.

According to the existing estimations, direct social expenditures related to the harmful impact of traditional power engineering, including diseases and reduction of the people's life span, payment for the medical service, industrial losses, harvest decrease, necessity to restore forests and buildings repairs as a result of air, soil and water pollution, form a content adding about 75% of the world's prices for fuel and energy. Essentially, these expenditures are environmental tax, which is distributed to the expenditures of the whole society for imperfection of the energy systems and installations. If to take into consideration invisible expenditures in energy tariffs, the majority of new technologies of renewable power engineering will become competitive in comparison with existing technologies. Exactly such "environmental" tax at the rate of 10%-30% of the oil price has been instituted in Denmark, Finland, Netherlands and, probably, will be introduced in EEC countries.

Economic estimations show that RES are quite competitive, particularly, their cost price 1.1 – 4 times lower in comparison with the traditional sources. One of the advantages of RES is the fact that they do not require high operational expenditures, in majority of cases they amount to less than 3-5% of the equipment cost. Estimations are based on the current prices and with their growth such indices as the cost price and recoupment will reduce.

Table 6. Dynamics of Pollutants Emissions in Major Industries of Republic of Uzbekistan (thous. tons)

Industries of Uzbekistan	**1999г.**	**2000г.**	**2001г.**	**2002г.**	**2003г.**	**2004г.**
Republic of Uzbekistan	776,95	755,52	711,84	729,48	672,57	646,51
Power industry	259,26	255,47	211,31	229,47	210,66	200,22
Oil and gas industry	259,62	241,25	247,84	222,37	192,97	186,88
Metallurgy	118,24	123,58	120,99	119,84	121,55	130,46
Municipal economy	31,84	27,02	32,87	59,57	50,18	43,45
Chemical industry	18,94	20,01	18,00	16,72	17,56	18,55
Building industry	32,96	27,56	27,52	22,38	19,58	20,46

Source – *National Report of Uzbekistan "On State of Environment" 2004.*

9. Conclusion

Traditional power engineering based on the organic fuel causes significant damage to environment. During producing energy due to the fuel combustion 150 M.tn of ash, 100 – sulfur dioxide, 60 – nitrogen oxide, 300 M.tn carbon dioxide, carbonic acid gas and many other substances, which absorb the Earth-emitted radiation appearing from the Earth surface, is emitted into the atmosphere every year. These admixtures can survive in the atmosphere for up to 120 years (carbon dioxide – 3 days, carbonic acid gas – 5 days, freon – 50 – 70 years, nitrous oxide 120 years), and their long-term presence in the atmosphere might result in undesirable climate changes. According to forecasts of scientists the further rise of average global air temperature is to be anticipated in comparison with the last century by 1-2°C., by 2025 year by 2-3°C, by 2050 year – by 3-50°C. This will mainly happen because of the accumulation of CO2 and other gases of anthropogenic origin. As a result a "greenhouse effect "is formed, which significantly impacts the climate change.

One of the tasks in the field of environment protection is the prevention of pollution of our ecosystem and decrease of anthropogenic impact on the climate change, using when possible environmentally friendly non-traditional renewable energy sources-sun, wind, geothermal water, etc. Currently, there is an urgent necessity in investigating the energy potential of renewable energy sources:

- analysis and estimation of energy potential of incoming solar radiation and on its basis conduction of theoretical investigations and development of measures for its utilization;
- analysis of wind-based energy resources and on its basis development of a cartogram of wind load and methods of their utilization as well as conduction of investigations on efficacy of wind-energy plants;
- analysis and examination of biotechnologies and development of measures for production of electric power;
- examination of potential of water power production on small watercourses, etc.

Based on the studies of energy potential of renewable energy sources it is necessary to develop concepts of RES development for the period 2020 – 2030 in CA countries, and on their basis to develop State Action Programs for certain countries and Subregional Concept of RES Development and utilization in CAR.

Fig. 7. Solar power in domestic use

References

1. Rational and Efficient Utilization of Energy Resources in Central Asia. Report of the Center of Energy Policy. M., 2001.
2. Tajiev U. A. et al. Outlooks of Sustainable Environmentally Safe Energy Supply of Uzbekistan with the Use of Solar Radiation Energy, Small Watercourses, Wind. International Journal "Geoliotekhnika" 1997. # 5-6, pp. 86-97.
3. Material of the International Central Asian – European Conference on Solar Energy Utilization. Tashkent, 2003.
4. Resources of Renewable Energy Sources and Scenarios of their Utilization / Report of the Institute of Power Engineering and Automation AS RUz. Tashkent, 1998.
5. National Energy Program of Strategic Development of Fuel and Energy Complex of Kyrgyz Republic for 2006 - 2010. Draft. – BBishkek, 2006.
6. National Program "Strategy of Economic, Political and Cultural Development of Turkmenistan for the Period till 2020". Ashkhabad, 2003.
7. Strebkov D. S., Murugov V.R Energy Saving and Renewable Energy Sources. Bulletin of Agricultural Science- M., Agropromizdat, 1991, #2.
8. Decree of the Cabinet of Ministers of Republic of Uzbekistan #476 of 26.12.1996: "On Development of Small Hydro-power Engineering in Republic of Uzbekistan".
9. "Development and Substantiation of Initial Data for Perspective Projects on Utilization in Uzbekistan / Report UNPZ "ECO.-Technology NUR." Tashkent, 2005.
10. Solar Energy Use. Ashkhabad, Ylym, 1985.
11. N. Korpeyev. Solar installations in Turkmenistan. Caspian. Mobil Corporation, London, 1996.
12. Vedenev A. G., Vedeneva T A. Biogas Technologies in Kyrgyz Republic / Under the general editorship of the Head of sub-faculty of KRSU Rodina E. M. Reference Manual. – Bishkek, "Evro", 2006. – 90p.
13. Wood M., Fulop L. Environment and development: Why energy matters. Sun World, June 1992, vol.16, 2.
14. Hohmeyer O. Social Cost of Energy Consumption. Springer-Verlag, New York, 1988.
15. Yu. S. Vasilyev, N.I. Hrisanov. Ecology of use of renewable energy sources. Leningrad, LSTU, 1991.
16. Assessment Report on Renewable Energy Sources Potential in Tajikistan.
17. Assessment Report on RES Potential in CA Countries (Turkmenistan).
18. Potential in Central Asia. Assessment Report of Kyrgyz Republic.
19. Assessment Report – RES (Republic of Kazakhstan).
20. Statistical collection "Environment Protection and Sustainable Development of Republic of Kazakhstan, Almaty 2005, Statistical Agency of Republic of Kazakhstan.
21. Statistical collection "Fuel and Energy Balance of Republic of Kazakhstan for 2002004" Almaty 2005, Statistical Agency of Republic of Kazakhstan.
22. Conference materials "Strategic Role of Renewable Energy Sources in Sustainable Development of Central Asian States", Almaty, Kazakhstan 17-19 May 2006
23. Plan of power engineering development of Republic of Kazakhstan till the year 2030.

Abbreviations

ARI	Aerosol Radiation Impact
ABC	Atmospheric Brown Cloud
FAO	Food and Agricultural Organization
GEF	Global Environmental Facility
IFSC	International Forum on the Safe Chemistry Intergovernmental forum on safe chemistry. The international organization is established in 1994 with a view to provide a free collaboration between government and other interested parties, including nongovernmental organizations. The activities of the Organization are carried out by its secretariat. The 6th forum of the IFSC to be held in Senegal in 2009.
ILO	International Labour Organization
IOMC	Interorgnizational Program for Safe Management of Chemicals
SAICM	Strategic Approach for international management of chemicals. The international organization is established in 2004. Its activity is carried out by secretariat.
UNDP	United Nations Development Program
UNIDO	United Nations Development Industrial Development
UNEP	United Nations Environment Program
WHO	World Health Organization
AC	Academy of Science
SC	Stock Company
AOT	Aerosol Optical Depth
WB	World Bank
GDP	Gross Domestic Product
RES	Renewable Energy Source
AM	Air Masses
WHO	World Health Organization
VSEGINGEO	All-Union Institute of Hydrogeology and Engineering Geology
WPS	Wind Power Stations
GIS	Geographic Information System
GCM	Global Climatic Model
HPS	Hydroelectric Power Station
GEF	Global Environmental Facility
EEC	European Economic Community
HDI	Human Development Index
UNCSD	United Nations Commission on Sustainable Development
LST	Lidar Station Teploklyuchenka
PL	Power Line
ICSD	Interstate Commission for Sustainable Development
MS	Meteostation
MES	Ministry of Extraordinary Situations
NGO	Non-governmental Organization
OECD	Organization for Economic Cooperation and Development

UN United Nations Organization

LLC Limited Liability Company

BT Back Trajectories

DS Dust Storm

PAFZ Planetary Altitudinal Frontal Zone

DFI Direct Foreign Investments

RGS Russian Geographical Society

REAP Regional Environmental Action Plan

RT Republic of Tajikistan

CIS Commonwealth of Independent States

SECC Solar Energy Supply System

TORP Turkmenbashi Oil Refinery Plant

TPS Thermoelectric Power Station

HPP Heat and Power Plant

CA Central Asia

CAR Central Asia Region

EC Electronic Computer

UNEP United Nations Environment Program

Tables and illustrations

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