Capacity Building
to Address Climate Change
Related Problems

INITIAL NATIONAL COMMUNICATION OF THE REPUBLIC OF UZBEKISTAN UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Phase 2

2001

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PROJECT IMPLEMENTATION REPORT

UZBEKISTAN: COUNTRY STUDY ON CLIMATE CHANGE, PHASE 2:
"Expedited Financing of Climate Change Enabling Activities"

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Introduction

The First National Communication of the Republic of Uzbekistan on the implementation of the UN Framework Convention on Climate Change (UNFCCC) was presented at the Fifth Conference of Parties to the Convention in Bonn in 1999.

The key element in the First National Communication was a register of gases having direct and indirect greenhouse effect that do not fall under the Montreal Protocol. The register was compiled in conformity with the 1996 Revised Handbook of the Intergovernmental Panel on Climate Change (IPCC). The national register contains an inventory of greenhouse gas sources (GHG) and their emission in the two benchmark years – 1990 and 1994. An essential component of the National Communication was a long-term forecast of GHG emission for the period until 2010, guidelines of activities aiming to reduce GHG emission and a list of interventions in this sector. The First National Communication contains a preliminary assessment of susceptibility to climate change of individual components of the environment and major economic sectors, and outlines possible ways of adaptation to climate change in Uzbekistan.

The present Report prepared within the framework of Phase 2 of the Project is a continuation and an integral part of the First National Communication. The specific Project objectives were both to deal with certain shortcomings and improve the National Communication in the following areas:

- Identifying priority technological requirements of economic sectors of Uzbekistan in reducing GHG emission and mitigating the negative impact of climate change; studying possible acquisition and use of technologies; assessing and developing specific technological projects.
- Undertaking additional studies in vulnerability assessment and developing climate change adaptation interventions.
- Strengthening the regional monitoring system and capacity building for participation in the Global Climate Monitoring System (GCMS).

Chapter 1 of the Report deals with the technological aspects of GHG emission reduction in the key sectors, namely, power engineering, oil and gas industry, and the chemical sector. The annexes contain proposed technological projects aiming to reduce GHG emission in these sectors. The Report also deals with the problem of a wide application of renewable energy sources as well as some aspects of the investment environment and technology market in the country.

Chapter 2 contains the outputs of water resources vulnerability assessment with due regard for the peculiarities of agriculture and water management development and vegetation modelling of several farm crops. The chapter assesses the impact of climate change on the level of thermal pressure on human and animal organisms, and a probability of climatic extremes under various climate change scenarios. It also traces the linkage between climate change and land degradation in the region and presents a list of possible interventions to reduce the negative impact of climate change. The chapter assesses the current condition of the national monitoring network and identifies priority requirements of its strengthening and full-scale participation in the Global Climate Monitoring System. One of the outputs of the implemented project is the preparation of the 2000 Climate Monitoring Newsletter of Uzbekistan.

Background. The Republic of Uzbekistan is situated in an arid zone of Asia, between the latitude of 37º and 45º North and between the longitude of 56º and 73º East. Its territory is 447,400 square kilometres. Plains occupy the greater part of the territory - 79 per cent, the rest is under mountains and mountain foothills. Uzbekistan borders on Kazakhstan in the North and West, Turkmenistan and Afghanistan in the South, and Tajikistan and Kirghizia in the East.

The climate in Uzbekistan is sharply continental. The average temperature in July varies between 26º C in the North and 30º C in the South, with the maximum temperature reaching 45-47º C. The average air temperature in January varies between minus 8º C in the North of the country and 0º C in the South. Deserts and semi-deserts, with an annual precipitation of 80 to 200 mm, occupy over 70 per cent of the country's territory. In the mountains the total annual precipitation is 600 to 800 mm and more.

The Republic of Uzbekistan is the largest Central Asian country as regards population. In 2000 it surpassed 24.5 million. Since 1990 through 2000 the population grew by 21.6 percent, with the urban population constituting 37.6 per cent.

Uzbekistan is a both agricultural and industrial country, with agriculture based on irrigated crop farming (cotton), which dominates its economy. Various industries are developing with the assistance of foreign investments. Contrary to the other CIS countries, Uzbekistan did not experience a considerable production decline in the post-Soviet period.

The gross national product had been steadily growing since 1996, and in 2000 reached US $2,994 in terms of per capita purchasing power (PPP).

Chapter 1. Priority Technological Requirements of Economic Sectors of Uzbekistan in Reducing Greenhouse Gas Emission and Mitigating the Negative Impact of Climate Change

The interests of the country's sustainable development require regular modernisation of its industrial capacities and improvement of technologies as well as a higher energy efficiency in the use of natural resources based on new, preferably environmentally friendly technologies.

Identification of technological requirements of the country's economy intended to prevent any negative impact of climate change and mitigate its effect on the economy will promote national economic development. The achievement and maintenance of the economic growth should meet the environmental standards and priorities.

In selecting the technologies intended to mitigate and reduce the negative impact of climate change the following criteria have been applied:

- Importance of economic sectors for purposes of GHG emission reduction;
- Assessment of existing technologies;
- Interaction and compatibility with other technologies;
- Stability in emission reduction and project implementation periods;
- Amounts of GHG emission reduction to be achieved by the application of technologies;
- Environmental, economic and social importance of technologies;
- Possibility of further improvement and replication.

1.1.Identification of Key Economic Sectors for Assessing Technological Requirements

National technological requirements embrace a wide range of GHG emission reduction and adaptation technologies. In conformity with the First National Communication, reduction in GHG emission in power engineering, higher energy efficiency in the housing sector, reduction of methane leakage in the oil and gas sector and a wider application of renewable energy resources are priority areas in the use of environmentally friendly technologies.

As regards adaptation technologies, a sustainable use of water resources, land degradation control, expansion of reforestation and pastures improvement are highly important.

Technological requirements of priority sectors are based on the GHG inventory data for 1990 and 1994 as well as an assessment of the latest inventory data for the period up to 1999.

Greenhouse gas emission in key economic sectors. Uzbekistan conducts a permanent monitoring of GHG emission in accordance with the guidelines of the Intergovernmental Panel on Climate Change (IPCC) in 21 sectors of the following five categories of their sources: power engineering, industry, agriculture, land use changes and forestry, and wastes.

Monitoring embraces the emission of the three following gases with a direct greenhouse effect, namely, carbon dioxide, methane and nitrous oxide. Besides that, the emission of gases with an indirect greenhouse effect such as carbon oxide, nitric oxide, sulphur dioxide and non-methane carbons (NMC) is computed.

At present almost 74 per cent of GHG emission in Power Engineering is related to technological processes involved in burning fuel. The remaining emission in this category includes methane leaks in the oil and gas sector (99 per cent of all volatile emissions in this category) and the coal-mining industry. Their aggregate share had been growing and reached 26.1 per cent in 1999 against 20.4 per cent in 1990. In burning fuel a major source of GHG emission are power-engineering enterprises, domestic consumers and transport. They account for more than 78 per cent of all emission related to burning fuel. Major GHG emission sources in Agriculture are soils and intestine fermentation products of farm animals, in Industry these are the production of mineral and chemical products, and in the Wastes category - solid wastes landfills.

Major GHG emitters in Uzbekistan are enterprises and agencies of ‘Uzbekenergo’ State Joint Stock Company, ‘Uzbekneftegaz’ National Corporation, ‘Uzkhimprom’ Association, ‘Uzkommunhizmat’ Uzbek Agency, construction materials industry, ‘Kyzylkumredmetzoloto’ Geological Prospecting Administration, Ministry of Agriculture and Water Resources, ‘Uzbeklegprom’ Association and the khokimiyats as well as the Almalyk mining and metallurgical works, the Uzbek metal plant and vehicles of ‘Uzbekiston Temir Yullari’ (Uzbekistan Railway), ‘Tashgorpasstrans’ (Tashkent Passenger Transportation) and ‘Uzbekiston Havo Yullari’ (Uzbekistan Airways) companies.

According to the Handbook on Best Practices for National Greenhouse Gas Inventory, key sectors are those that account for at least 95 per cent of the aggregate national GHG emission. Ten out of the 21 sectors under observation in Uzbekistan meet this definition.

According to assessment, from 1994 through 1999 (see Table 1.1) GHG emission in the 10 key sectors has grown by 4 per cent, with a considerable increase in the share of domestic consumers (burning fuel), and oil and gas sector (methane leak). The share of the power engineering., transportation and industry in burning fuel has decreased.

Therefore priority economic sectors requiring urgent interventions to reduce GHG emission are these:

- Production of electric and thermal energy – 25.6 per cent;
- Extraction, refining and transportation of natural gas and oil – 22.2 per cent;
- Domestic consumers and municipal sector – 25.8 per cent;
- Transport – 6.7 per cent;
- Agricultural lands – 5.4 per cent.

It is clear from Table 1.1 that in 1999 GHG emission in Uzbekistan reached 160.5 million tons in terms of CO_2 equivalent and constitutes 0.7 per cent of the total global GHG emission.

The per capita GHG emission in Uzbekistan is 6.6 tons, which exceeds the world average of 3.9 tons and coincides with the emission indicators of such countries as France and Spain. In 1999 each billion soums of the produced GDP (in 1995 prices) was accompanied by a GHG emission of 0.45 million tons.

GHG emission forecast. Forecast options of emission of major GHG (CO_2, CH_4 and N_2O) for the period up to 2010 in the four categories such as the power engineering, industry, agriculture and wastes show that in 2010, depending on economic development options and emission reduction interventions, GHG emission may constitute from 185.6 million to 209.0 million tons in term of the CO_2 equivalent, and GHG emission structure as well as its sources structure will not change.

The main greenhouse gas will be carbon dioxide (depending on the option, its share may constitute from 65 to 70 per cent), methane will account for 29 to 25 per cent of emission, and the remaining amount of 5 to 6 per cent will fall on the nitrous oxide.

The main GHG sources will be those falling under the category of power engineering, the share of which will constitute 83 to 86 per cent of the aggregate emission. The share of agriculture will be no more than 10 per cent, and the combined share of industry and wastes will approximately constitute 5 per cent.

Thus, according to the GHG emission forecast no radical changes in its structure is expected for the period up to 2010.

Table 1.1. GHG emission by economic sectors and categories of sources

Key sectors Gg (000 tons) CO_2-equivalent	**1990**			**1994**			**1999 assessment**		
		Share %	**% cumul.**		**Share, %**	**% cumul.**		**Share, %**	**% cumul.**
Total GHG emission	163204			154153			160469		
Power engineering, CO_2 burn	54698	33,52	33,52	44785	29,05	29,05	41219	25,69	25,69
Oil & gas systems, CH_4 pe	27259	16,70	50,22	30365	19,70	48,75	35574	22,17	47,86
Domestic consumers, CO_2 burn	12239	7,50	57,72	22588	14,65	63,40	32411	20,20	68,05
Transport, CO_2 burn	17326	10,62	78,79	9006	5,84	82,37	10692	6,66	85,48
Agricultural lands, N_2O Agr	10221	6,26	68,17	9846	6,39	76,52	8764	5,46	78,82
Municipal sector, CO_2 burn	6841	4,19	61,91	10382	6,73	70,14	8514	5,31	73,36
Intestine fermentation, CH_4 cx	5829	3,57	82,36	6707	4,35	86,72	6510	4,06	89,54
Industry CO_2 & construction, burn	10736	6,58	88,94	6263	4,06	90,78	5349	3,33	92,87
Agriculture, CO_2 burn	5667	3,47	92,41	3855	2,50	93,28	3145	1,96	94,83
Solid wastes, CH_4 wastes	2924	1,79	94,20	3054	1,98	95,26	2963	1,85	96,68

Cement production , CO_2 ind	2572	1,58	95,78	2093	1,36	96,62	1491	0,93	97,61
Ammonia production, CO_2 ind	2625	1,61	97,39	1838	1,19	97,81	1136	0,71	98,32
Manure, CH_4 agr	799	0,49	97,88	916	0,59	98,41	892	0,56	98,87
Steel production, CO_2 ind	998	0,61	98,49	774	0,50	98,91	569	0,35	99,23
Rice growing, CH_4 agr	262	0,16	98,96	228	0,19	99,31	263	0,16	99,52
Coal extraction & CH_4 processing, pe	469	0,29	99,24	275	0,18	99,49	252	0,16	99,67
Manure, N_2O agr	285	0,17	99,42	260	0,17	99,66	171	0,11	99,78
Domestic wastewater, CH_4 Wastes	180	0,11	99,74	188	0,12	99,94	198	0,12	99,95
Lime production,	354	0,22	99,63	238	0,15	99,81	76	0,05	99,83
Nitric acid	391	0,24	99,98	78	0,05	99,99	68	0,04	99,99
Industrial wastewater,	26	0,02	100,0	21	0,01	100.00	11	0,01	100,0

Note: burn – burning; pe- power engineering; ind – industry; agr – agriculture.

Possibilities and interventions aiming to reduce GHG emission. Technical possibilities of reducing GHG emission (not including renewable energy sources), as assessed in the First National Communication of the Republic of Uzbekistan on Climate Change constitute 27.2 million tons in terms of CO_2 equivalent.

The category of power engineering harbours the biggest possibilities of GHG emission reduction in the order of 25 million tons. The categories of industry, agriculture and wastes may permit a reduction of up to 2.2 million tons in terms of CO_2 equivalent.

To implement these possible GHG emission reductions the following interventions are required:

- improvement and introduction of energy-saving equipment in production sphere;
- reduction of losses and improvement of technology in using fuel and energy;
- introduction of natural gas, heat, water and energy consumption meters;
- improvement of information systems for the transfer of environmentally friendly technologies;
- reform of legal norms in the area of environmental protection;
- higher public awareness of problems of climate change, the need for energy saving and effective technologies.

1.2.Identification of Technological Requirements in Economic Sectors of Uzbekistan

Low energy efficiency remains the main problem in the power engineering, oil and gas and industrial sectors. Lack of required accounting and control over the use of energy carriers as well as slow renewal of production assets due to a shortage of funds and difficulties in obtaining credits at favourable terms have a negative impact on interventions aiming to raise energy efficiency.

A limited use of energy-saving technologies including equipment and renewable energy sources, contribute to a high energy consumption of technologies, which is considerably higher than similar indicators in industrialised countries.

The current growth of total production output as well as increasing consumption of electric and thermal energy and fuel by internal combustion engines in the country have revealed areas requiring higher energy efficiency in the following priority economic sectors.

1.2.1 Electric Power Engineering

The main producers of electric power in Uzbekistan are **thermoelectric power plants (TEPP)** operating on organic fuel and generating about 80 per cent of electricity, and **hydroelectric power plants (HEPP).**

TEPPs use solid, liquid and gas fuel. Coal accounts for 4-5 per cent of power generation in Uzbekistan while fuel oil and gas for 10-11 and 84-85 per cent respectively. The aggregate installed capacity of the power system in Uzbekistan is 11,264 Mw.

Electricity is generated in Uzbekistan at thermoelectric power plants of the following two types – condensation steam-turbine power pants (CPP) generating only electric power, and heating plants (HP) generating and supplying two types of power – electric and thermal ones.

Efficiency of CPP in Uzbekistan does not exceed 33 per cent. The CO_2 emission is currently 640 g/kWh. Specific fuel consumption by CPPs for generating electricity is approximately 380 g/kWh.

The capacity of HPs is approximately 650 Mw or 6 per cent of the aggregate power system capacity, while electricity generation constitutes 4.4 per cent. Thanks to utilisation of the used heat the HPs save fuel for power generation. Specific consumption of fuel for power generation at HPs does not exceed 210 g/kWh. Construction of additional HPs in Uzbekistan is rather limited due to lack of major demand for steam and heat.

One of the most important ways of raising the efficiency of power generation in the country is modernisation of the existing capacities and replacement of outdated equipment with more efficient one.

Table 1.2 presents key technologies used in the power-engineering sector of Uzbekistan.

Table 1.2 Key technologies in the power-engineering sector of Uzbekistan

Sector	Technology
Electric power engineering	Introduction of new technologies for power generation with steam-and-gas turbines at TEPPs. Large-scale introduction of small hydroelectric power plants and renewable energy sources. Introduction of water-accumulating power plants. Introduction of gas-expansion equipment for utilising excessive pressure in gas pipelines.

Introduction of energy-saving equipment (gas-expansion machines – GEM) and the use of steam-and-gas (SGU) as well as gas-turbine units (GTU) are the most effective ways of raising energy efficiency of electric power plants.

Table 1.3. Characteristics of steam-and-gas (SGU) and gas-turbine units (GTU)

Indicator		Unit of measure	Station				
			TashGRES (SGU)	NavGRES (SGU)	TashTEC (GTUHP)	MubTEC (GTUHP)	Bukh EM (GTU HP)
Capacity	Electric Thermal	Mw Gcal/h	370 78	350 150	64 71	106 260	62 72
Annual output	Electricity Thermal energy	Million kWh 000 Gcal	2800 267	2650 821	486 552	850 2000	463 330
Specific fuel consumption for:	Electricity Thermal energy	G/kWh Kg/Gcal	225 170	232 170	152 170	158 155	172 155
Fuel saved		000 tons conv. fuel/year	434	458	106	220	96
CO_2 emission rate		G/kWh	370	380	250	260	280
Reduction of CO_2 emission		000 tons conv. fuel/year	710	750	175	362	165
Year of commissioning			2005	2008	2010	2008	2007

A considerable reduction of CO_2 emission (one million tons a year) can be achieved by introducing combined generation of thermal and electric power at half of the existing boiler houses as regards hot water supply alone (Table 1.3).

Hydroelectric power plants (HEPPs) utilising the energy of falling water generate up to 15 per cent of power in Uzbekistan (5-7 billion kWh). It should be noted that 90 per cent of hydroelectric units have already exceeded their service life.

Construction of the Pskem HEPP with a capacity of 404 Mw is currently under consideration. The planned annual power generation at Pskem will be in the order of 900 million kWh, which is equivalent to 300,000 tons of conventional fuel saved annually or reduction of the carbon dioxide emission by one million tons in case of coal replacement. Construction of the hydroelectric power plant will permit to achieve peak capacity and participate in regulating frequency in the power system. The Pskem water reservoir with a capacity of 520.8 million m^3 is intended for seasonal regulation of the Pskem River water run-off in the interests of raising water provision in that area and creating additional irrigated lands.

The potential capacity of ***small-scale hydraulic power engineering***, i.e. small HEPPs with a capacity of less than 10 Mw constitutes up to 8 billion kWh, which corresponds to a 5.2 million ton reduction of carbon dioxide emission. The Ministry of Water Resources and Agriculture of Uzbekistan has designed a scheme of development of small HEPPs for a period until 2010. The scheme substantiates a technical possibility of construction of 43 small HEPPs near water reservoirs and 98 small HEPPs on irrigation canals with an aggregate capacity of approximately 400 Mw.

The construction of ***water-accumulating electric power plants*** (WAEPPs) has good prospects in Uzbekistan. They consume electricity in periods of small load (at night) for pumping water into the upper reservoir and generate it in the period of peak load thus relieving electric power plants operating on organic fuel from participation in regulating the frequency and capacity in the power system and thereby reducing use of organic fuel and greenhouse gas emission. At present the Hydroproject Institute in Uzbekistan is designing options of WAEPPs construction in various parts of the country.

Use of the ***solar and wind energy for large-scale power engineering*** does not hold industrial significance in Uzbekistan although it may be applied in facilities remote from electric transmission lines as well as for heat and hot water generation and supply.

Therefore, of all renewable energy sources only hydroelectric power plants may serve as a feasible alternative to thermoelectric power plants.

For energy efficiency of electric power engineering the ***conditions and structure of distribution networks*** securing energy transportation and distribution are highly important. Electricity to consumers in Tashkent City is mostly supplied through cable networks put into operation in 1966 through 1972 and requiring modernisation. Intensive construction of new facilities and development of the city infrastructure require modernisation of electricity supply lines. Implementation of projects aiming to rehabilitate electricity supply lines will reduce the CO_2 emission by 85,000 tons annually.

Of great practical importance are the ***issues of saving electricity in the electric power-engineering sector itself***, which consumes 5.6 per cent of all electric energy generated by TEPPs for its own purposes and 7.5 per cent of energy for its transportation. Phase 1 of the energy-saving programme stipulates for the introduction of tested energy-saving engineering and logistical interventions not requiring any considerable expenses and producing a maximum effect within the shortest possible time. Their introduction into electric power engineering may reduce the annual CO_2 emission by approximately one million tons. The total possible reduction of GHG emission in electric power engineering is 7 to 8 million tons annually, and considering small-scale power engineering such possible reduction may achieve 12 to 13 million tons.

The total GHG emission in the electric power-engineering sector is at present approximately 32 million tons, or 20 per cent of the total GHG emission in the country. According to forecasts, GHG emission will reach 38.3 million tons in 2005 and 44 million tons in 2010. This is connected with the increasing electricity generation due to the growing requirements of the national economy, and also with the growing share of burnt coal related to the fact that Uzbekistan has been lately changing the structure of the fuel-and-energy balance in favour of coal and cutting gas consumption. Therefore the share of coal in power engineering of Uzbekistan will grow from 4.7 per cent in 2000 to 9.1 per cent in 2005 and to 17.5 per cent in 2010.

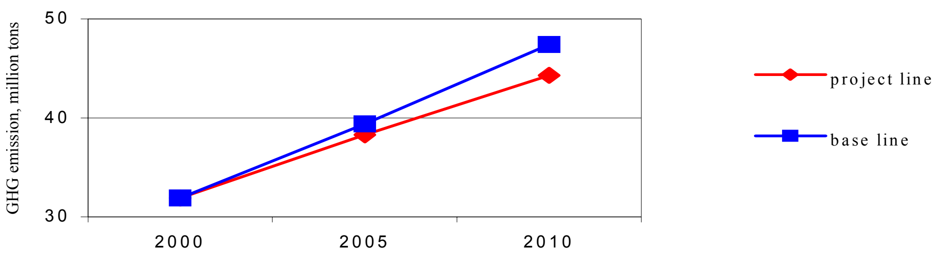
Total reduction in GHG emission as a result of implementation of the proposed projects in the power-engineering sector is presented in Table 1.4.

Table 1.4. Projects proposed for implementation in power engineering

Project name	Capital investments (000 $)	Annual reduction in GHG emission (000 tons)
Modernisation of Navoi SREPP including construction of gas-and-steam unit with a capacity of 350 Mw.	232 000	751
Modernisation of Tashkent SREPP including construction of gas-and-steam unit with a capacity of 370 Mw.	221 000	710
Modernisation of Tashkent HP including construction of gas turbine unit with a capacity of 64 Mw.	22 000	175
Modernisation of 'Bukharenergomarkez' open-end joint-stock company including construction of gas turbine unit with a capacity of 62 Mw.	40 000	165
Construction of Pskem HEPP with a capacity of 404 Mw.	420 000	1000
Modernisation of Mubarek HP including construction of gas turbine unit with a capacity of 106 Mw.	98 900	362
Introduction of energy-saving unit at Talimarjan SREPP based on gas expansion machine DGA-5000.	2 500	12,6
Construction of wind-powered electric stations	6000	14
TOTAL	**1 042400**	**3 189,6**

Reduction of GHG emission in power engineering thanks to the implementation of the above interventions, as compared to the base line (without the project implementation), is presented in Fig. 1.1.

Fig. 1.1. Reduction of GHG emission in power engineering



1.2.2. Heat Supply to Consumers in Uzbekistan

Centralised heat supply. Over 7.0 million tons of conventional fuel, or 12 per cent of total fuel consumption in Uzbekistan, are spent on heat generation annually. Technological processes involved in the production of thermal energy are major sources of greenhouse gases. Electric power stations and boiler houses with a capacity of 3 Gcal/hour and more supplying thermal energy in the form of steam and hot water are responsible for almost 10 per cent of total GHG emission in the country.

In Uzbekistan heat is supplied to production consumers, the social sector and the population both from centralised (electric power plants in general use, district and neighbourhood boiler houses) and isolated sources (heating plants of industrial enterprises, local boiler houses and individual heat sources). Some requirements in thermal energy of industrial consumers and the social sector are met by non-heating sources such as utilisation units and electric boilers.

Table 1.5 presents amounts and structure of supply and consumption of thermal energy in Uzbekistan in 1999 – 2001.

Table 1.5. Thermal energy balance in Uzbekistan (Gcal)

Heat supply & consumption structure	1998 г.	1999 г.	2000 г.
SUPPLIED – total	49,2	45,4	46,4
Of this amount to:			
Electric power plants	13,0	12,2	12,6
Boiler houses with a capacity of 3 Gcal/h & more	33,7	30,6	31,4
Other sources (non-heating)	2,5	2,7	2,4
DELIVERED – total	49,2	45,4	46,4
Of this amount to:			
Power-engineering sector	9,4	8,9	9,1
Of this amount: losses	2,1	2,1	2,1
For end consumption	39,8	36,5	37,4
Of this amount:			
Industry	14,8	13,4	13,7
Construction	0,2	0,1	0,1
Agriculture	0,1	0,1	0,1
Population	14,4	14,9	15,6
Public utilities & others	10,4	8,0	7,8

More than one third of the thermal energy supplied are spent on heating and hot water supply to the population. The share of the social sector is significant and constitutes almost 17 per cent. Consumers are provided with heat both from centralised and isolated sources, especially in towns, settlements and rural areas.

Centralised heat supply to consumers is well developed in all major cities of Uzbekistan. In all of them the heat supply system does not include any meters installed at consumers' places. Such a system is inefficient and unreliable since considerable amounts of heat (4.5 per cent of the total supply) are lost during transportation along main heat supply lines from the source to the consumer.

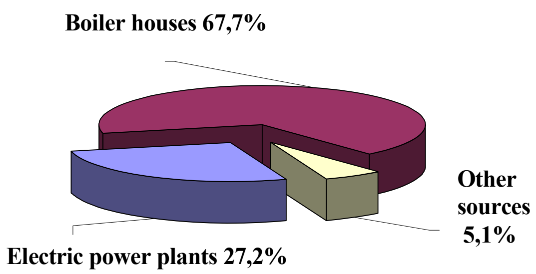


Fig. 1.2 Structure of thermal energy supply in Uzbekistan in 2000

In industry a considerable amount of thermal energy is spent on oil and natural gas refining (approximately 15 per cent), production of chemical goods (approximately 3 per cent), mechanical engineering, manufacture of cotton and silk fabrics, food products and canned foods, construction materials and reinforced concrete structures. Most industrial enterprises meet their requirements in thermal energy from their own sources such as heating plants and boiler houses, and only partially – from centralised ones.The structure of heat supply by sources is presented in Fig. 1.2.

The main suppliers of thermal energy are boiler houses, which account for over two thirds of total supply. There are over 7,500 boiler houses of various capacities in Uzbekistan where almost 25,000 boilers of various types and designs are installed. At the end of 2000 the number of boiler houses with a capacity of 3 to 1000 Gcal/h alone reached 1,186.

Heat generation. Boiler houses. The technological base of municipal thermal power engineering was mostly formed some 25 to 35 years ago in conditions of complete technological and energy sufficiency, when the issues of accelerated and large-scale provision of the population in cities and towns with centralised heat were addressed.

Boiler houses belong to various departments. Prior to this year the most powerful of them (with a capacity of over 100 Gcal/hour) were mostly operated by ‘Uzbekenergo’ State Join-Stock Company. In 2001 the Government of the Republic of Uzbekistan, with the aim of furthering the process of demonopolisation, privatisation and corporatisation of power-engineering enterprises, decided to turn over all district boiler houses to local authorities. The share of “Uzbekenergo”, which constituted almost half of total heat supply in the country, will now be considerably decreased.

The design efficiency of the largest and most advanced boilers is 90 to 92 per cent, while their actual efficiency is only 50 to 75 per cent. The output of thermal energy from boiler houses is not controlled due to the absence of meters. The metering of heat consumption by end consumers is also practically absent. The output of heat is computed by boiler houses staff indirectly, based on the indications of two water consumption meters, with a measurement error of over 5 per cent. Only 0.4 per cent of the 70,000 industrial, agricultural and domestic consumers have meters. Despite the high technical parameters of the existing equipment in medium and large boiler houses, the actual energy efficiency does not meet the required standards because this equipment is outdated.

Due to absence of production of effective small boiler units, a considerable number of boilers with a low efficiency of 60 to 75 per cent were installed in small boiler houses. Such boilers produce over 40 per cent of thermal energy in municipal power engineering. Lack of production of modern small boilers as well as automation and control equipment and boiler pipes in Uzbekistan is a considerable barrier to maintaining an efficient operation of boiler houses. Operation of boiler equipment in medium and small boiler houses under an incomplete technological cycle due to lack of required water treatment, smoke exhausters and ventilators leads to accelerated external and internal corrosion of heat supply lines and blockage of distribution networks. The period of operation of boiler pipes is thereby reduced to half of the design one. Operation of small boiler houses with ineffective equipment under a curtailed technological scheme results in over-consumption of fuel and energy resources and, therefore, in a higher cost of the heat produced. No modernisation of boiler house is undertaken because of lack of funds in the sector.

Heat supply lines. Heat supply lines, along which heat is delivered to consumers and distributed among them, are the most vulnerable spot in the heat supply system. The total length of municipal heat supply lines in Uzbekistan is 3,945 km in two-pipe calculus.

Accelerated corrosion of heat supply lines, especially those laid under the ground, is explained by a rising groundwater table and submersion of heat supply routes by drainage and irrigation water and causes their rapid wear and tear. The cause of a considerable heat loss during transportation is a considerable length of heat supply lines, especially in the event of centralised heat supply. Outdated technologies of pipe insulation with mineral wool covers are used in Uzbekistan, leading to considerable losses of heat during transportation.

Lack of manufacture of pipes with medium and large diameters, locks and modern pipe insulation materials such as ceramic and polymeric covers makes the repair and maintenance of heat supply lines more difficult and lowers the efficiency of heat supply.

Possible energy saving in heat supply lines in case of application of effective modern insulation materials may amount to 5-7 per cent, which will permit to save up to 250,000-300,000 Gcal annually.

The GEF/UNDP/Government of Uzbekistan Project ‘Removing barriers to energy efficiency in municipal heat and hot water supply’ has permitted to expose a lot of problems related to low energy efficiency of the heat supply to the social sector and residents of Tashkent City, which consume more than half of the heat supplied to the population of Uzbekistan. An analysis of conditions of the centralised heat supply system in Tashkent has permitted to identify the main technological constraints of municipal power engineering such as:

- dependent connection of the heating load with an open water distribution scheme;
- low efficiency of heat generation equipment in small boiler houses;
- inadequate heat insulation in heat supply lines;
- intensive external and internal corrosion of pipelines;
- absence of heat meters;
- major heat losses in buildings due to their imperfect design and construction materials;
- low extent of use of combined generation (of electric and thermal energy);
- a number of logistical problems such as:
    - unreasonably low tariffs;
    - insufficient payment collection;
    - lack of a system of payment for actual consumption;
    - lack of funds;
    - inadequate organisational structure;
    - insufficient legislative regulation of heat consumption.

The findings and recommendations of the study aiming to raise the energy efficiency of heat supply are true of most departmental heat sources and heat supply systems in Uzbekistan. They provided a basis for six pilot projects proposed for implementation at boiler houses of various sizes in Tashkent City.

1. ‘Mashinostroitelnaya’ boiler house: Project cost – \$145,700; emission reduction – 403 tons of CO_2 annually. Phases of the Project include the laying of plastic piles for hot water supply, rehabilitation of intake conduits, modernisation of in-house hot water supply systems with installation of meters, installation of new boilers in the boiler house and introduction of a closed system in it, installation of 50 m^2 of solar panels in the boiler house as well as thermostatic valves and thermal distributors at heating radiators in apartments.
2. TVRZ area heat supply network: Project cost – \$544,700; emission reduction – 1,600 tons of CO_2 annually. The project includes introduction of a closed system for improving water quality and minimising leaks by the installation of heat exchangers for heating water; installation of hot and cold water meters; rehabilitation of internal water supply; in-house energy conservation interventions; installation of thermostatic valves at radiators and evaporation heat distributors;

installation of solar panels for pre-heating of return water; replacement of boilers in the boiler house; and in the subsequent phase – installation of heat meters and implementation of in-house energy conservation measures to be arranged by local house committees as well as modification of the system including introduction of differential pressure valves, two-pipe heating systems in buildings, connection of towel-dryers to return pipes, and replacement of pipes with modern pre-insulated ones.

3. HP-8 modernisation: Project cost - $446,000, emission reduction – 11,350 tons of CO_2 annually. The Project includes consecutive activities related to visual inspection of the network, pipe insulation, drying of canals, fuel burning management in boiler houses, establishment of a large-scale solar heat-supply station, introduction of circular connection and closed systems, modernisation of line and consumer devices and laying of pre-insulated pipes.
4. Establishment of a major heat-supply plant: Project cost - $ 261,000, emission reduction – 658,700 tons of CO_2 annually. The project includes the delivery of 500 m^2 of solar panels, and components for local assembly of 1,500 m^2 of panels, heat exchangers, pumps, filtering equipment as well as automation and control devices.
5. Establishment of a plant for the assembly of solar panels: Project cost – US $155,000, emission reduction – 330,000 tons of CO_2 annually from each 1,000 m^2 of panels. The project includes the delivery of components for the assembly of solar panels and assembly equipment.
6. Institutional interventions in apartment houses: Project cost – US $25,000. The Project aims to establish local housing committees to manage heat and hot water supply in buildings and implement energy conservation measures.

Table 1.6. Projects proposed for the heat supply sector

Project name	Capital investments (000 USD)	Annual GHG emission reduction (000 tons)
Modernisation of Machinostroitelnaya boiling house	145,7	0,403
Improvement of TVRZ area heat supply system	544,7	1,6
Modernisation of HP-8 heating plant	446	11,35
Establishment of a big heat supply station	261	658,7
Establishment of a solar panels assembly plant	155	0,330
Formation of local heat, hot water and electricity supply committees	25	
ИТОГО	**1577,4**	**672,383**

Table 1.7. Key technologies in the heat supply sector

Sector	Technologies
Municipal housing sector	Introduction of heat, natural gas and water consumption meters. Municipal heat and hot water supply. Introduction of independent heat supply systems and closed hot water supply schemes. Introduction of modern lighting equipment.

1.2.3. Oil and Gas Sector

The oil and gas sector of Uzbekistan is developing dynamically. In 2000 approximately 7.7 million tons of oil and gas condensate and about 56 billion cu m of natural gas were extracted, which is 2.7 and 1.4 times respectively higher than the 1991 level. The share of the oil and gas industry in the country's GDP is 3.3 per cent.

The oil and gas industry of Uzbekistan falls under the jurisdiction of "Uzbekneftegaz' National Holding Company (NHC) – a major production and economic complex securing a wide range of activities starting with the exploration of oil and gas deposits and ending with the sale of end products for which oil and gas are used as raw materials.

The NHC is comprised of 17 subdivisions, the largest of them are as follows:

1. "Uzbekneftegazdobycha' Joint-Stock Company (JSC) (43.5 per cent of the NHC total output) extracting oil and natural gas and refining natural gas with the production of gas sulphur, liquid gas and stable condensate.
2. 'Uzgaztrans' JSC (27.8 per cent of the NHC total output) securing transportation of natural gas and its underground storage for covering seasonal consumption irregularities.
3. 'Uzneftepererabotka" JSC (28.7 per cent of the NHC total output) refining crude oil and stable condensate into oil products.

Oil and gas extraction and gas refining. As regards the oil, condensate and gas output (96-97 per cent) and gas refining (100 per cent), the largest subdivisions of 'Uzbekneftegazdobycha' JSC are enterprises situated in Kashkadarya Province.

An analysis of the existing technologies of natural gas and oil extraction as well as the production of gas condensate and oil refining has shown that the following processes account for the largest emission of greenhouse gases:

- the burning of emergency and technologically required natural gas disposal in flare systems;
- the burning of natural gas in technological and domestic boiler houses as fuel;
- the burning of tail gases from Klaus sulphur production facilities (Mubarek gas refining plant) and direct oxidation sulphur production facilities (Mubarek plant and Shurtanneftegaz oil and gas refining facility) in after-burning furnaces;
- the burning of gas in heating furnaces at condensate stabilisation facilities (Mubarek plant and Shurtanneftegaz oil and gas refining facility);
- the burning of gas at absorption and adsorption sulphur-cleaning facilities, and natural gas drying facilities (fire regenerators, heating furnaces);
- leaks through fixture connections in oil and gas collection systems, during preliminary and integrated gas preparation for remote transportation, and during pre-treatment and storage of oil and gas condensate.

Therefore, a major reserve of cutting GHG emission lies in the introduction of modern flare facilities, maximum utilisation of valuable flare gases components, application of modern thermal energy generation plants, modernisation of the existing heat supply lines, maximum extraction of sulphur from tail gases in Klaus facilities, modernisation of condensate stabilisation plants, replacement of the physically and morally outdated equipment in oil and gas extraction and refining as well as introduction of fuel gas and thermal energy meters, use of energy efficient lamps, etc.

However, financial constraints in the oil and gas sector, lack of domestic production of the required equipment, high taxes and lack of internal currency exchange put up barriers to the implementation of the above interventions.

Oil refining. As regards the emission of gases with a direct greenhouse effect (such as CO_2, CH_4) the share of oil refining in the power-engineering sector is insignificant. However, the entire range of oil products (gasoline, aviation kerosene, diesel fuel, furnace fuel, fuel oil and others) produce GHG emission when fuel is burnt in various economic sectors.

Crude oil is mostly refined at Bukhara, Ferghana and Altynaryk oil refineries (OR), where equipment, with the exception of the Bukhara OR, is outdated.

The largest GHG discharge is observed both in emergency and technological disposal similar to operations involved in oil and gas extraction and refining, and in some specific processes such as:

- leaks and discharge during storage of oil products in tank pools;
- evaporation from purification facilities in various systems.

Thus, GHG emission may be reduced by:

- technological modernisation of tank pools and railway flyovers;
- maximum coverage of purification facilities evaporation surface;
- utilisation of valuable components of flare gases;
- application of modern facilities in thermal energy generation;
- replacement of physically and morally outdated equipment;
- improvement of energy efficiency.

Since technological requirements of OR vary, individual approaches to their modernisation should be taken.

The Bukhara OR based on the unique technology of the French company Technip with the participation of Japanese partners is a modern enterprise manufacturing products meeting international requirements.

The technological cycle at the Ferghana OR requires modernisation in the following areas:

- use of a 100 per cent of the flue gas in technological furnaces raises the issue of their purification;
- imbalance of air streams through burners, and in some cases work with large amounts of excessive air leads to overuse of fuel, which, in its turn, results in higher emission of nitrogen oxides (NO_x) and carbon dioxide as well as low energy efficiency; therefore the operation of tube furnaces requires modernisation by regulating the oxygen regime;
- considerable methane emissions are present during storage in tanks with immobile covers as well as during loading and unloading on railway flyovers; therefore, a system of capturing carbon dioxide during storage, loading and unloading should be established.

The Altynaryk OR is an enterprise producing fuel. It requires in-depth modernisation of its technological cycle and replacement of its morally and physically outdated equipment.

Table 1.8. Key technologies in the oil-refining sub-sector of the oil and gas sector

Sub-sector	Technologies
Oil refining	Introduction of a gas-fractionating plant with a capacity of 150,000 tons of reforming limit gases at the Ferghana OR; Introduction of technology improving the quality of fuel in order to reduce the emission into the atmosphere of harmful substances including lead in gasoline – 0.15 g/kg; Use of alternative kinds of fuel in automobile transport.

Gas transportation along main pipelines. The system of main gas transportation in Uzbekistan is represented by 'Uztransgaz' Joint-Stock Company. A lot of equipment, mostly large-diameter pipelines, is involved in this process, and most of it has been in operation for a considerably long time and therefore has a considerable depreciation, which defines the gas industry as rather funds-intensive.

Natural gas transportation consists of the following stages:

- reception of gas from suppliers (gas fields, gas refineries and other systems);

- long-distance gas transportation;
- the pumping of gas into underground storage reservoirs and its withdrawal as required;
- gas distribution among wholesale and direct consumers.

Practically the entire methane emission during gas transportation along mains is determined by the amount of natural gas discharged during operations intended for technological requirements of enterprises as well as technological losses due to lack of leak-proofness of equipment and breakdowns. All this is combined in the notion of 'own requirements and losses'. In 2000 the total amount of gas lost and used by "Uztransgaz' JSC for its own requirements was equal to 3.6 billion m^3 (according to references).

Losses constituted 365 million m^3 or 0.8 per cent of the amount of the sold gas.

Of this amount:	leaks in gas pipelines	-	360 million m^3;
	leaks in gas distribution networks	-	2 million m^3;
	losses at compressor stations	-	3 million m^3.

Uztransgas uses 2.7 billion m^3 or approximately 6 per cent of the amount of the gas sold for its own needs.

Of this amount:

fuel for gas pumping units	-	870 million m^3;
gas for heating purposes	-	22 million m^3;
technological requirements of compressor stations & gas mains	-	14 million m^3;
blow-down of purification facilities	-	1,394 million m^3;
cleaning of gas pipelines	-	225 million m^3;
liquidation of breakdowns & hydrates	-	152 million m^3;
technological requirements of transit gas storage	-	18 million m^3.

Most leaks occur in gas pipelines and gas processing units using fuel gas, and during blow-down of purification facilities.

Gas losses in supply lines of gas mains occur in case of pipe rupture, therefore a reduction in the accident rate on pipelines will decrease methane emission. The introduction of telemetry and teleautomatics will reduce losses due to pipe rupture 2 to 3 times over. Gas losses in the supply lines of the gas mains at gas distribution and compressor stations will be reduced by the application of a better valve lubricant, which will fill loose spaces and thus prevent gas leaks. Unfortunately, in the past few years the issue of delivery of the valve lubricant has become increasingly pressing due to lack of its manufacturers in Uzbekistan.

The application of such lubricant will cut gas losses by approximately 200 million m^3. Besides that, it is possible to reduce gas emission due to technological causes during planned repair of pipelines by using compressor of ejector units pumping out gas from those parts of the pipelines that are under repair.

The technological needs of compressor and gas distribution stations as well as underground gas storage stations are caused by the use of equipment, which requires gas discharge into the atmosphere as a part of the technological process. Therefore, there can be no question of cutting the emission due to this cause.

Most considerable are emissions due to the blow-down of purification facilities, the cleaning of pipelines, and liquidation of breakdowns and hydrate formations. All these activities are not caused by the specific operation of gas pipelines and their systems, and are induced. Even considering the shortcomings of the regulatory framework, gas losses due to these requirements amounted in 1995 to 711 million m^3 or 1.17 of the normal amount. In 2000 such losses reached 1.771 billion m^3, which is twice as high as the norm. The increase in gas losses is related to the low quality of gas supplied to the main pipelines by ‘Uzgeoneftegazdobycha’ JSC and lack of tertiary treatment equipment in the main pipelines.

The most promising technologies as regards GHG emission reduction in the oil and gas sector are presented in Table 1.9.

Table 1.9. Key technologies in the oil and gas sector

Sector	Technologies
Oil and gas sector	Modernisation of flare facilities. Utilisation of associated gas. Energy conservation technologies in gas transportation. Reduction of gas leaks in main pipelines. Utilisation of excessive pressure in main pipelines. Deeper processing of carbohydrates.

Thus, the oil-and-gas sector of Uzbekistan harbours considerable reserves of reducing gas emission into the atmosphere.

The greenhouse gas emission, mostly methane (in terms of CO_2 equivalent) considerably increased in 1995 to 2000 due to the growing volume of natural gas output and transportation.

In the future an insignificant increase in GHG emission is expected (from 41.6 million tons in 2000 to 43 million tons in 2015) because in this period of time the output will stabilise at approximately 56 billion m^3 annually.

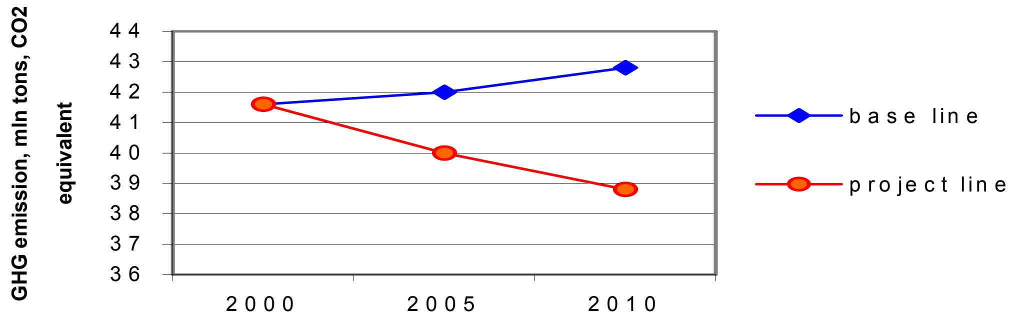
The aggregate reduction in GHG emission in the sector from the proposed projects is presented in Table 1.10.

Table 1.10. Projects proposed for implementation in the oil and gas sector

Project name	Capital investments (000 USD)	Annual reduction of GHG emission (000 tons)
Utilisation of associated gases from Kokdumalak oil and gas condensate deposit at Mubarek oil and gas refining plant	82 003	1135
Installation of facilities for waste gases tertiary treatment by the Scott method at Mubarek gas refinery	28 318	148
Assembly of a system of automatic control of the composition of waste gases and the load as well as the sulpheretted hydrogen and oxygen at Mubarek GR	848	60
Installation of facilities for tertiary treatment of waste gases by the catalyst cold layer adsorption at Mubarek GR	2 287	79
Gas fractionating facility at Ferghana OR	76 782	208
Modernisation of the flare system in the head facilities at Shurtanneftegaz OGRF	59 534	474
Second stage of sulphur production by direct oxidation at Mubarek GR	870	26
Modernisation of the flare system at Mubarek GR	60 000	497
Modernisation of boiler houses at Mubarek GR	2 500	52,6
Modernisation of compressor stations at Mubarek GR	63 810	111
Modernisation of compressor stations in Gazli	100 000	154
Reduction of natural gas leaks at compressor stations	3 800	641
Reduction of natural gas leaks in the supply lines of gas mains	64 000	147
TOTAL	**544 752**	**3 732,6**

As is shown in Fig. 1.3, in case of project implementation the GHG emission in the oil and gas sector will be reduced by 3.78 million tons in 2015, that is from 43 to 39.2 million tons in terms of the CO_2 equivalent.

Fig. 1.3. Reduction of GHG emission in the oil and gas sector



1.2.4. Chemical Industry

The chemical industry of Uzbekistan is comprised of 22 enterprises. They produce mineral fertilisers, chemicals, chemical fibres and raw materials for them, rubber articles, paints and lacquers, domestic chemicals, hydrolysis products, perfumery, etc. The output of the chemical industry constitutes approximately 5 per cent of the country's total industrial output.

The wear and tear of the active part of the main assets in the chemical industry has exceeded 50 per cent. Lack of centralised funds for technical modernisation has considerably promoted deterioration of technical and economic indicators of chemical industrial enterprises.

Due to the application of morally and physically outdated equipment utilisation of fuel and energy in the chemical industry is highly intensive and exceeds 1.2 to 2 times energy consumption by chemical industries in developed countries. The chemical industry of Uzbekistan consumes 2,376,200 m^3 of gas, including 1,568,000 m^3 as a technological raw material, and 3,569,100 kW/h of electricity. The greater part of gas (85 per cent) and electricity (88 per cent) is consumed by nitrogen-producing enterprises.

A radical reconstruction and technical modernisation of the existing chemical enterprises based on perspective energy-efficient technologies capable of reducing the emission of greenhouse gases such as the carbon dioxide is the main avenue for achieving a substantial energy conservation in the sector and maintaining a high production level.

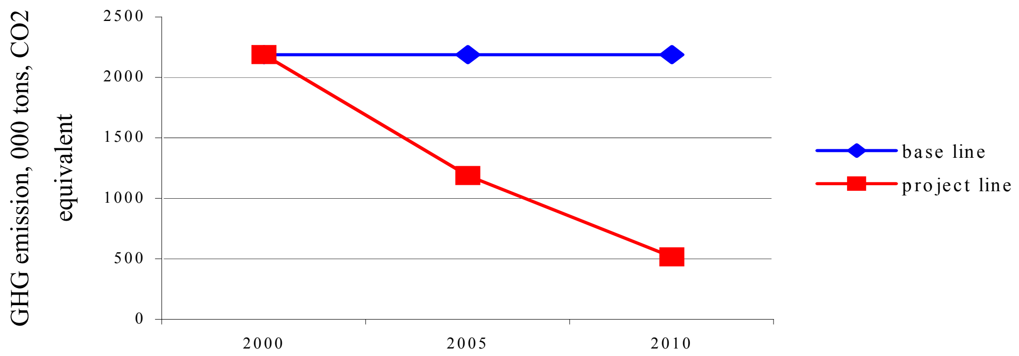
Table 1.11. Projects proposed for implementation in the chemical industry.

Project name	Capital investments (000 USD)	Annual GHG emission reduction (000 tons)
Reconstruction of carbamide production at 'AZOT' production amalgamation in Ferghana	71000	138
Reconstruction of carbamide production at 'Chirchikelectrochimprom' PA	59660	127
Construction of a new ammonia-producing unit at 'Chirchikelectrochimprom' PA	263 560	205
Reconstruction of a large-capacity ammonia-producing unit at 'AZOT' PA in Ferghana	25 000	357
Reconstruction of a large-capacity ammonia-producing unit at 'Chirchikelectrochimprom' PA	25 000	357
Construction of an energy facility at 'Navoiazot' PA	136 600	343
Establishment of carbamide production at 'Navoiazot' PA	71000	220
TOTAL	**651 820**	**1747**

This includes:

- use of carbon dioxide obtained as a by-product of main technological processes for producing ammonia in the manufacture of carbamide;
- provision of raw materials for the production of new chemical products.

Fig. 1.4. Greenhouse gas emission reduction in chemical industry



In 2000 the CO_2 emission per one ton of chemical products was 0.934 tons. Implementation of interventions aiming to utilise the emitted CO_2 will permit to cut the emission down to 0.462 tons per one ton of products by 2005 and to 0.170 tons by 2010.

The aggregate reduction in GHG emission in the chemical industry thanks to the implementation of the proposed projects is presented in Table 1.11.

Reduction of GHG emission in the chemical industry thanks to the implementation of the proposed projects is illustrated in Fig. 1.4.

1.2.5. Construction Materials Industry

Construction materials industry accounts for 3.2 per cent of consumption of all boiler and furnace fuel in Uzbekistan. Technological processes related to the production of cement (73.6 per cent of the total consumption of boiler and furnace fuel in construction materials industry) and bricks (15.7 per cent) are most energy-intensive.

Comparative energy efficiency in the sector against industrialised countries is 0.7 to 0.9 depending on the type of product, namely: reinforced concrete structures approximately 0.77, bricks approximately 0.7, porous aggregates 0.76, and thermal energy production approximately 0.87. The construction materials industry harbours considerable reserves of raising its energy efficiency and reducing GHG emission, which may be transformed into life by implementing interventions such as modernisation of the existing pool of technological units, machinery and equipment; technological interventions (introduction of a 'dry' cement production method instead of the 'wet' one); reconstruction and technological modernisation of the existing enterprises as well as utilisation of non-traditional and renewable energy sources (such as the introduction of solar technologies in the production of reinforced concrete structures).

Cement production. At present there are six cement-producing plants in Uzbekistan operating under the umbrella of 'Uzkurilishmaterialmollari' Joint Stock Company. Their aggregate design capacity is 6.45 million tons annually, while the actual production output was about 3.3 million tons annually in 1995 through 1998.

Enterprises of the cement-producing industry of Uzbekistan are characterised by a high wear and tear of its main equipment, energy consumption and production cost, and lack of exhaust gas purification facilities.

Cement consumption in Uzbekistan tends to grow. Per capita consumption will rise to 250 kg and more, which will lead to the general demand of 7 to 8 million tons in 2010.

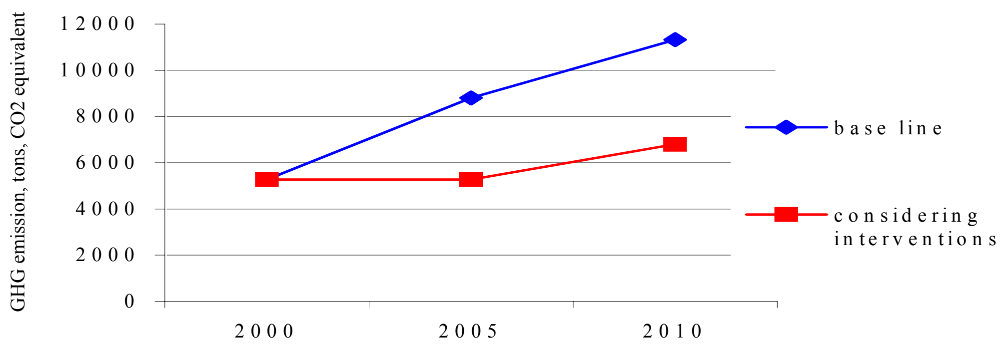
The development of the cement-producing industry will be connected with a radical reconstruction and modernisation of the existing enterprises and introduction of modern energy- and resource-saving and environmentally friendly technologies thanks to involvement and rational use of local and foreign credits and foreign investments. The total reduction in GHG emission in the construction materials industry thanks to the implementation of the proposed projects is presented in Table 1.12.

Table 1.12. Projects to be implemented in the construction materials industry

Project name	Capital investments (000 USD)	Annual reduction of GHG emission (000 tons)
Modernisation of 'Bekabadcement' JSC including replacement of the 'wet' technology with the 'dry' one	84 400	193
Modernisation of 'Ahangarancement' JSC including replacement of the 'wet' technology with the 'dry' one	87 200	245
Modernisation of 'Kuwasaicement' JSC including replacement of the 'wet' technology with the 'dry' one	87 200	179
Modernisation of glassware production at 'Kwartz' JSC	6 000	15
TOTAL	**264 800**	**632**

The key energy-saving technology aiming to reduce GHG emission in the cement-producing industry is the replacement of the 'wet' technology with the 'dry' one.

Fig. 1.5. Reduction of GHG emission in construction materials industry



In 2010 reduction in HG emission in case of implementation of interventions in the cement-producing industry will be down from 11,000 to 7,000 tons (Fig. 1.5).

12.6. Transport

Uzbekistan has a well-developed transportation sector including automobile, railway, air and river transport and pipelines. The share of transport in the total carbon dioxide emission exceeds 9 per cent. The automobile transport takes the lead both in development rates and carbon dioxide emission growth. Its share in the transportation sector accounts for more than 60 per cent. The establishment of domestic production of cars and mini-buses has considerably alleviated the problem of replacing outdated and energy-inefficient cars. However, the problem of renewing the existing transport pool, mostly trucks, with energy-efficient vehicles remains sufficiently acute.

The main areas harbouring reserves of energy conservation in transport are these:

- introduction of diesel engines, which is key to providing transport with quality fuel;
- availability of required resources of diesel fuels in the oil refining sector;
- use of condensed natural gas as local fuel in automobile transport, especially town buses;
- construction of gas compression filling stations;
- diversification of transport as regards load-carrying capacity and services;
- improvement of the vehicles pool structure;
- use of electric traction in railways;
- development of town electric traction transport;
- optimisation of freight and passenger transportation schemes.

A programme of reducing gas emission by automobile transport is being designed in Uzbekistan. It includes the development of an engineering strategy and interventions aiming to reduce gas emission in the automobile sector and proposals on improving the legal and regulatory framework on air protection in the Republic of Uzbekistan.

The programme will deal with such important issues of mitigating the impact of the automobile transport on the environment as control over the volume and concentration of exhaust gases from the automobile transport, improvement of the vehicles pool structure and the traffic system, large-scale use of liquid natural gas in automobile transport, development of a legal and regulatory framework for the sector and reduction of GHG emission (see Table 1.13).

Table 1.13. Key technologies in the transport sector

Sector	Technologies
Transport	Use of liquid gas by vehicles. Diversification of vehicles. Introduction of diesel engines in automobile transport.

1.2.7. Agriculture

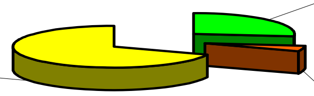
Uzbekistan, being an agrarian as well as an industrial country, with an overwhelming share of agriculture in its economy, a rapidly growing population, its practically exhausted available water resources and deteriorating condition of irrigated land is primarily interested in the development of agriculture and its radical rearrangement.

The country's agriculture accounts for approximately 70 per cent of the domestic goods turnover and 50 per cent of currency receipts, mostly due to cotton export. Uzbekistan, which produces 1.5 million tons of cotton fibre annually, is the world's fifth largest cotton producer and second largest exporter. The annual export of seed cotton is 3 million tons. Agriculture gives employment to approximately 45 per cent of the country's labour force. It consumes 6 per cent of the country's fuel and energy resources.

Of primary importance for agricultural production is the use of electricity, the share of which is at present 16 per cent of total energy consumption. The share of energy consumption in agricultural production is approximately 77 per cent, and that of domestic consumption is 23 per cent. Electric power availability per worker is approximately 5,000 kW/h.

The structure of electricity consumption in agriculture is illustrated in Fig. 1.6.

Fig. 1.6. Electricity consumption in agricultural production of Uzbekistan



Since electricity consumption by irrigation constitutes the bulk of electricity consumption in agricultural production, special attention should be paid to energy conservation in this sector.

Given the existing technologies of farm crop growing and water consumption volumes, energy conservation reserves in irrigation constitute 200,000 tons in terms of oil equivalent. In the event of application of more progressive techniques and less water-consuming crops the amount of the energy saved may be increased.

Top priority interventions in energy conservation in agriculture are:

- wide use of latest farming methods in raising crop yields;
- modernisation of irrigation facilities and farm machinery;
- interventions aiming to reduce farm crop losses;
- implementation of a programme of rational use of water and energy resources in irrigation systems;
- rational use of mineral fertilisers;
- introduction of economic incentives to energy conservation in agricultural production;
- introduction of state policies of a phased reduction of subsidies to energy consumption in irrigation and agricultural production.

The share of agriculture in the emission of gases with a direct greenhouse effect does not exceed 11 to 12 per cent. The largest emission of 54.6 per cent is from agricultural soils and 37.2 per cent from intestine fermentation of farm animals.

The amounts of GHG emission from 1990 through 1999 are presented in Table 1.14.

Table 1.14. Emission of gases in agriculture with a direct greenhouse effect, Gg, CO_2 equivalent

Categories of sources	CO_2			CH_4			N_2O			Total		
	1990	1994	1999 assess-ment	1990	1994	1999 assess-ment	1990	1994	1999 assess-ment	1990	1994	1999 assess-ment
1. Power engineering in agriculture	5667	3855	3145							5667	3855	3145
Of this amount:												
Mobile	3933	2874	2561							3933	2874	2561
Stationary	1734	981	585							1734	981	585
Agriculture				6890	7910	7623	10506	10106	9067	17396	18016	16690
Of this amount:												
Intestine fermentation				5829	6706	6474				5829	6706	6474
Manure				799	916	887	285	260	226	1084	1177	1113
Rice growing				262	288	262				262	288	262

Agricultural soils							10221	9846	8841	1022	9846	8841

A considerable reduction of GHG emission in agricultural production is possible in the following events:

- improvement of rice-growing technology (reduction of methane emission down to 10-15 per cent per unit of produce);
- optimisation of use of water resources in irrigation as well as land crop patterns and application of nitrogen fertilisers (reduction in nitrous oxide) down to 10-15 per cent against applied norms);
- better conditions of livestock maintenance, well-balanced fodder, optimisation of the number of heads of livestock considering the highest pressure on pastures given regular cleaning, disposal of animal refuse and wastewater withdrawal with their subsequent utilisation;
- use of modern pumps and electric engines with a low CO_2 content in exhaust gases, modernisation of the farm machinery pool and energy conservation.

Thus, main technological requirements in agriculture as regards GHG emission reduction are aiming to raise crop yields, improve the quality of farm produce, reduce specific water consumption per unit of produce and raise soil fertility based on the introduction of modern perspective technologies in all sectors of crop farming and livestock husbandry.

Table 1.15. Key technologies in agriculture

Sector	Technologies
Agriculture	Use of agricultural biomass and wastes for energy generation. Introduction of metering and consumption control of fuel and energy resources.

1.2.8. Forestry

Forests are natural long-term absorbers of the carbon dioxide. As CO_2 sinks, forests of Uzbekistan have an estimated technical capacity of 2.53 million tons annually. GHG emission in forestry is related to forest clearing and transformation of pastures and meadows into arable lands.

Forest clearing. Legislation of Uzbekistan makes no provisions for forest clearing. Moreover, the cutting of trees and shrubs is only permitted in the event of compulsory subsequent reforestation.

The forestry of Uzbekistan has a number of specific peculiarities. The overwhelming majority of natural forests in the country are unproductive and sparse, and therefore a very small amount of cut wood remains after main clearings.

Due to a low capacity of forestry farms and their dispersion across the country's territory, especially in the desert area, the calculated cutting area is not completely cleared, and wood is procured in limited amounts. Actually, in the past decade from 1990 to 2000 from 50,000 to 80,000 m^3 of wood were cut annually, and 95 per cent of it was firewood, which was obviously insufficient for the population.

In rural areas local population can only use firewood as domestic fuel, and so they pick brushwood in places of felling.

On January 1, 1998 the annual (based on the three-year count) wood procurement constituted approximately 54,000 m^3, which, in terms of carbon dioxide, is equal to 67.1 Gg of CO_2, or approximately 8 per cent of the total CO_2 sink into all forests of Uzbekistan. Assuming that a certain amount of the biomass is burnt in places of felling, this amount will be negligible as compared to the amount of the wood cut. Thus, no substantial burning of wood occurs in felling places.

Transformation of pastures and meadows. In 1998 the State Forestry Reserve (SFR) of Uzbekistan included 1,140,305 hectares of pastures, 612 hectares of hayfields and 13,946 hectares of arable lands. Pastures and hayfields are classified as non-forest lands, and this means that they are not intended for afforestation with arboreal species. It is difficult to transform this land into arable land without an additional costly improvement including irrigation. Most of these lands are situated in the desert area, and in these conditions rain-fed arable lands are either unproductive or entirely useless. Irrigation can hardly be counted on since water is provided to forestry in very limited amounts. All arable land is generally located in irrigated areas.

Thus, no practices exist in the SFR territory in Uzbekistan of transforming pastures and meadows into arable lands.

An analysis of the main sources of GHG emission into the atmosphere related to forestry of Uzbekistan has shown that neither the forestry in general, nor any individual technologies applied in it are major sources of GHG emission.

Technological requirements connected with the increase of carbon dioxide sinks in forestry. According to the IPCC, GHG sinks in forestry are related both to termination of use of lands (overgrowth of arable lands or pastures and meadows with forests) and the annual increase in the biomass in forests.

Termination of the use of lands. In the State Forest Reserve of Uzbekistan there are almost 14,000 hectares of irrigated arable lands, which are used intensively and for purposes they are intended for. Pastures are classified as non-forest lands, and for this reason no reforestation can be practised on arable lands without the costly additional improvement. Natural overgrowing with forests is difficult due to over-grazing of livestock, which occurs everywhere. Moreover, for this reason pastures begin to disintegrate.

Therefore, at present there are no grounds to count on natural overgrowing of arable lands and pastures.

Annual increase in the biomass in forests. The annual increase of the biomass in forests of Uzbekistan directly depends on their productivity. Therefore, when raising productivity of forests, we thereby simultaneously increase their capacity as CO_2 sinks.

In order to raise the productivity of forests with the aim of increasing the amount of carbon deposited by trees the following interventions are required:

- densification of low-density growths to a minimum density of 0.6 in mountain areas, 0.8 in tugai forests and 0.4-0.5 in deserts (the latter dominate in the State Forest Reserve);
- reforestation and afforestation on woodlands not actually covered by woods, densification of sparse growths, creation of growths on other woodlands not covered by woods (there are a lot of such areas in the SFR). There are 1,603,400 hectares of sparse growths in the SFR. Sparse growths are areas with a density of trees of less than 0.3, i.e. these areas are used inefficiently, and density of plants on such lands should be raised. The State Forest Reserve classifies slashes and land under dead plants occupying an area of 2,123 ha, openings occupying an area of 10,633 ha and glades occupying an area of 565,533 ha as woodlands. Creation of growths on such lands will permit to increase the areas under woods by 2,181,689 ha or 72 per cent;
- development of field-protective afforestation on irrigated and rain-fed arable lands, growing of arboreal species on plantations for mercantile wood, both on agricultural lands and on the lands of the SFR. Despite he limited area on which this can be done (250,000-300,000 ha), it harbours the main reserve of increasing the volume of sinks and the period of CO_2 deposition because it is on these lands that the most productive plantations may be created in conditions of irrigation;
- replacement of not valuable and unproductive species with productive ones based on selection of trees and shrubs;

- protection of woods against pests, diseases and fires.

All the above options are important for raising the productivity of forestry, they meet the national priorities, are of high importance for nature protection and have a high environmental and economic efficiency. However, not all of them are equally valuable as regards their capacity as CO_2 sinks.

The annual growth of carbon per one hectare is considered the key indicator of efficiency of forest ecosystems as CO_2 sinks. Forest plantations on arable, especially irrigated lands are especially effective. Their growth rate is higher than that in forest ecosystems situated in river valleys and floodplains, which, in their turn, absorb much more carbon than desert and mountain forest communities.

A considerable effect on the annual growth rate of carbon on the entire area of natural forests has such an extensive indicator as their area. Haloxylon forests have the highest carbon growth rate.

Densification of low-density growths up to a minimally acceptable density will permit to raise the annual carbon growth rate at least 1.5 times over. An increase in the carbon growth rate in proportion to this value is expected throughout the entire area of various groups of forests.

Reforestation and afforestation on woodlands not covered by woods as well as the development of protective and plantation afforestation on arable lands may considerably increase carbon growth rate in forest ecosystems given that these forests will be dense from the start. That is the expected CO_2 increase per hectare will be 1.5 times higher than the existing one.

The expected aggregate carbon increase and complete utilisation of all available reserves will permit to raise the sinks to 1,278,030 tons as compared to the current 283,280 tons, which will constitute a 4.5-fold increase. The most capacious sinks will be protective forest belts and forest plantations (approximately 56 per cent of the total area). Sinks into haloxylon may increase from 170 to 464,000 tons, which is 2.7 times over. Sinks into other natural forests ecosystems may also increase 2 to 3 times over, although it will be almost 1-2 times lower than into protective forest belts, forest plantations and haloxylon forests.

The most effective annual carbon increase will be achieved in the event of application of key technologies listed in Table 1.16.

Table 1.16. Key technologies in forestry

Sector	Technologies
Forestry	Protective afforestation and growing of forest species on plantations; Reforestation and growing of haloxylon, juniper and turanga trees on woodlands not covered by woods; Densification of low-density growths.

1.2.9. Wastes

Domestic solid wastes. At present 6.5 million tons of domestic solid wastes (DSW) are produced in Uzbekistan annually. They are collected, stored and disposed of in special landfills or dumping grounds. Of the total amount of DSW, only 2.3 million tons are stored and disposed of in improved landfills (Tashkent City), the remaining 4.7 million tons are practically stored in unmanaged dumping grounds. Storage of large amounts of wastes in dumping grounds leads to anaerobic decomposition of their organic matter and methane emission. A considerable source of methane is also active silt in city wastewater purification stations. In 1999 methane emissions from wastes constituted 3.0 million tons in terms of CO_2 equivalent, which is equal to 6.8 per cent of total methane emission.

A study of DSW in towns and district centres has revealed that:

- storage amount per resident was 1.1 cu m per year;
- specific weight of DSW was 0.58 to 0.68 tons/cu m.

The morphological composition of domestic solid wastes shows a considerable content of paper, food wastes, wood, textiles, leather and rubber. The calorific capacity of wastes depending on the season of the year constitutes from 1,508 to 2,507 Kcal/kg, which is sufficient for maintaining the burning process.

The burning of DSW with the aim of generating electricity and thermal energy as well as utilisation of the slams of burning products in the construction materials industry is rather promising. Computations have shown that in Uzbekistan approximately 2.2 million tons of domestic wastes can be used as alternative fuel annually, and it is possible to utilise the available structures and wastes collection and transportation systems on the spot. Major administrative centres including Tashkent City have good prospects in this respect.

Possible reduction in CO_2 annual emission in case of utilisation of 2.2 million tons of DSW will be 640,000 tons.

Generation of electricity and thermal energy based on biological gas from excessive active silt at purification facilities. Over one million tons of excessive silt is formed in sewage treatment facilities in Uzbekistan annually. Due to its biological properties, it requires considerable expenses as regards its disinfecting against various bacteria and eggs of worms. The existing technologies require considerable energy consumption. At the same time, there are modern technologies of high-temperature fermentation of wastes containing organic matter, by which methane can be obtained. The technology includes the treatment of active silt in special methane tanks where a temperature of 58º C is maintained. Disinfecting takes 72 hours, and a mixture of burning gases (90 per cent of which is methane) is formed as a result as well as an organic fertiliser. Methane is used for the generation of electric and thermal energy.

Table 1.17. Projects proposed for implementation in the solid wastes management sector

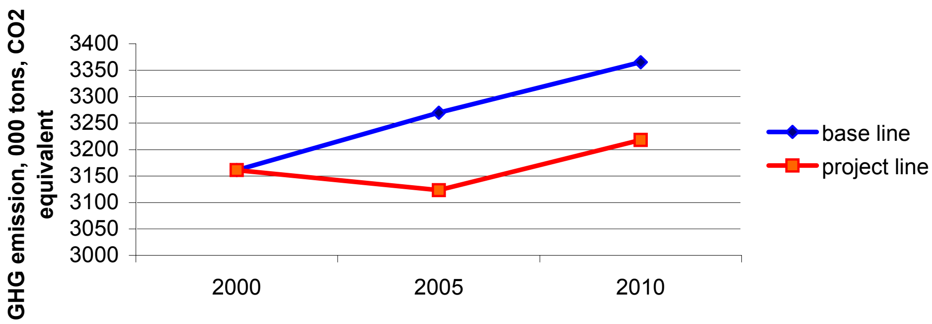
Project name	Capital investments (000 USD)	Annual reduction in GHG emission (000 tons)
Utilisation of domestic wastes as a low-calorie fuel (waste-incinerating plant in Samarkand City)	45000	128,1
Technology of generating electricity and thermal energy based on biological gas from excessive active silt at sewage treatment facilities in Tashkent City	8000	19
TOTAL	**53000**	**147,1**

Application of this technology permits to make sewage treatment facilities self-sufficient in electricity and thermal energy, supply its excessive amounts to the electric power grid, disinfect silt against micro-organisms and eggs of worms, and use the end product as a highly effective biological fertiliser.

Possible reduction in CO_2 annual emission in case of utilisation of active silt may achieve 57,000 tons.

The total reduction in GHG emission as a result of implementation of the two proposed projects in the solid wastes management sector will constitute 147,100 tons of CO_2, while capital investments into the projects will amount to US $53 million (see Table 1.17).

Fig. 1.7. Changes in GHG emission in the solid wastes management sector



Changes in CO_2 emission in the solid wastes management sector in case of implementation of the proposed projects and without their implementation are illustrated in Fig. 1.7.

Table 1.17. Key technologies in the solid wastes management sector

Sector	Technologies
Solid wastes management	Modern solid wastes utilisation technologies. Methane collection and utilisation from active silt in city sewage treatment facilities.

1.2.10. Renewable Energy Sources

The limited amount and impossibility of reusing natural fuel resources as well as a necessity of providing the economic sectors and the population with fuel and energy require involvement of alternative energy sources. These primarily include renewable energy sources (RES) such as hydraulic, wind, solar and geothermal energy, the biological mass, the biological gas and wastes, that is the sources and related technologies, which are applied or are close to application on an industrial scale.

The gross reserves of studied RES sources (hydraulic, solar, wind and geothermal energy and the biomass) in Uzbekistan constitute almost 51 billion tons in terms of oil equivalent. The technical reserve of these RES has been assessed at 179.3 million tons in terms of oil equivalent, of which only 0.6 million tons or 3 per cent are being utilised (see Table 1.19).

Table 1.19. Renewable energy sources

	Total	Energy				
		Hydraulic	Solar	Wind	Geo-thermal	Biomass
Gross reserves (million tons of o.e.)	50986,9	9,2	50973,0	2,2	0,2	2,3
Technical reserves (million tons of o.e.)	179,3	1,8	176,8	0,4	n/a	0,3
Utilised (million tons of o.e.)	0,6	0,6	0,0	0,0	0,0	0,0
TOTAL of the technical reserve utilised(%)	0,3	33,3	0,0	0,0	0,0	0,0

In the event of complete utilisation of technical reserves of renewable energy sources it is possible to replace such amounts of fuel, the burning of which produces 447.5 million tons of CO_2.

Hydraulic energy. Studies have revealed that the gross hydroelectric reserve of the main rivers of Uzbekistan is mostly concentrated in the following four parts of the country: the Chirchik-Angren basin (33.4 per cent of the gross reserve), the Ferghana Valley (24 per cent), the Southwest of Uzbekistan (34.8 per cent) and the lower reaches of the Amudarya River (7.8 per cent). It is more than 100 Tw/h, of which the technical reserve is over 21 Tw/h. The technical reserve of small-scale power engineering (i.e. waterways on which hydroelectric power plants with a capacity of up to 30 Mw can be built) is 10.4 Tw/h, i.e. half of the total technical reserve of the country's rivers. There is a technical possibility of building 250 hydroelectric power plants (HEPPs) with an aggregate capacity of 5.8 Gw on rivers, water reservoirs and canals in Uzbekistan.

By now only one third of this reserve has been utilised. Thirty one hydroelectric power plants with an installed capacity of 1.7 Gw and the annual electricity generation of 5 to 7 Tw/h have been built on rivers and water reservoirs. Major HEPPs are the Charvak (installed capacity of 620 Mw), Hojikent (165 Mw), Tuyamuyun (150 Mw), Andijan (140 Mw), Farhad (126 Mw) and Gazalkent (120 Mw) HEPPs.

The most promising are the following HEPPs: Pskem (installed capacity of 400 Mw), Tupolang (175 Mw), Ahangaran (20 Mw), Sokh (14 Mw) and a number of others with an aggregate annual generation of 5.5 billion kW/h. They have been included into the development programmes of the relevant sectors. Implementation of these projects will permit to replace the amount of fossil fuel, the burning of which will produce an emission of 1.1 million tons of CO_2.

Solar energy. The geographical position of Uzbekistan has predetermined the availability of a considerable solar energy reserve. According to observations duration of sunshine in various parts of the country varies between 2,413 and 3,095 hours annually, with a radiation balance of 1,718 to 2,722 Mj/m^2.

The gross reserve of the solar energy is assessed at 50,973 million tons in terms of oil equivalent. This constitutes 99.97 per cent of the gross reserve of all studied renewable energy sources in the country. This reserve is distributed unevenly throughout Uzbekistan. The largest solar energy reserve is in the Republic of Karakalpakstan (19,548 billion tons of o.e.), and the smallest is in Andijan Province (129 million tons of o.e.).

The technical reserve of the solar energy is assessed at 176.8 million tons of n.e. or 98 per cent of the total technical reserve of renewable energy sources in Uzbekistan.

The main methods of possible utilisation of the solar energy for electricity generation are direct conversion of solar radiation into electricity with the help of photoelectric converters, and conversion of the solar energy into low-reserve (for heating, hot water supply, air conditioning and drying) and high-reserve (for technological processes and electricity generation) heat.

The available solar energy reserve is not well utilised in Uzbekistan at present. It is mostly used for generating thermal energy for hot water supply and for smelting super-pure metals.

Wind energy. In Uzbekistan air currents have a seasonal nature due to the peculiarities of their origin and the country's geographical position on the Asian continent. In the plains the average annual wind velocity varies between 2 and 5 m/sec. The gross wind energy reserve in Uzbekistan is assessed at 2,223,200 tons in terms of oil equivalent, and is distributed throughout its territory extremely unevenly, from 4.,300 tons of o.e. in Ferghana Province to 924,700 tons in the Republic of Karakalpakstan. The average specific capacity of the wind current in Uzbekistan is 85 w/m^2 and varies from 20 w/m^2 in Andijan Province to 1,043 w/m^2 in Navoi Province.

The technical reserve of the wind energy is assessed at 426,900 tons of o.e.

Attempts at using wind-driven power plants (WDPP) of different capacity in various parts of Uzbekistan (such as remote areas of Navoi and Bukhara provinces and in the vicinity of the Farhad HEPP in Syrdarya Province) have yielded no expected results due to lack of substantial feasibility studies of the possible use of the wind energy in specific locations and unsubstantiated selection of WDPP parameters and characteristics.

The latest studies of Uzbek scientists have revealed a possibility of utilising the wind energy in a number of parts of the country.

There are localities (in the direction from the town of Bekabad to Kokand in Tashkent Province) dominated by winds with a velocity of over 6 m/sec and an annual repeatability of 42 per cent, where 400 wind-driven power plants with a total capacity of 240,000 kW and an annual electricity generation of over 800 million kW/h can be built.

Geothermal energy. Geothermal waters are available in practically all parts of Uzbekistan. Their average temperature across the country is 45.5º C, with the hottest water in Bukhara (56º C) and Syrdarya (50º C) provinces.

The gross reserve of the geothermal waters in Uzbekistan is assessed at 170,800 tons of n.e.. The largest reserve is in Bukhara (56,800 tons of o.e.) and Namangan (29,800 tons of n.e.) provinces. The technical reserve has not been assessed.

Biological mass. Forests cover an insignificant part of the territory of Uzbekistan (3.2 per cent of the total land area). The largest areas are under haloxylon, juniper and saltwort. All forests of Uzbekistan refer to Group 1, and commercial cutting there is forbidden. Only reforestation, sanitary and other non-commercial cutting is permitted.

Most of the country's agriculture is based on irrigated farming, and most lands are under cotton, cereals, rice and potatoes, whose tops are used as fodder for domestic animals or local fuel.

Studies have revealed that 2 to 4 tons of cotton stalks can be obtained from one hectare of land under cotton. The gross energy reserve of this biomass is assessed at 1.1 to 2.2 million tons of o.e., while the technical reserve (in case of the thermo-chemical conversion of the biomass) ranges from 0.13 to 0.26 million tons.

1.3. Capacity Building to Assess Technological Requirements

In conformity to Article 4.1 of the Convention the Parties shall build their national capacity in:

- Identifying their technological requirements;
- Assessing the role of technologies in mitigating climate change;
- Identifying mechanisms promoting the development of the technology market and strengthening business contacts for an effective technology transfer.

Uzbekistan currently needs to study ways and means of gaining access to and using technological data supplied by international centres, and to develop its national technological centre.

1.3.1. Building Logistical Capacity

The institutional structure of the national system for Convention implementation in Uzbekistan and collaboration with international agencies is presented in the First National Communication of the Republic of Uzbekistan on UNFCCC.

In 200 the Government of Uzbekistan placed direct responsibility for implementing the UNFCCC under the Chief Administration for Hydro-meteorology of the Republic of Uzbekistan (Glavhydromet). A relevant Secretariat has been established at Glavhydromet as a permanent body vested with the further implementation of national commitments of Uzbekistan under the Convention.

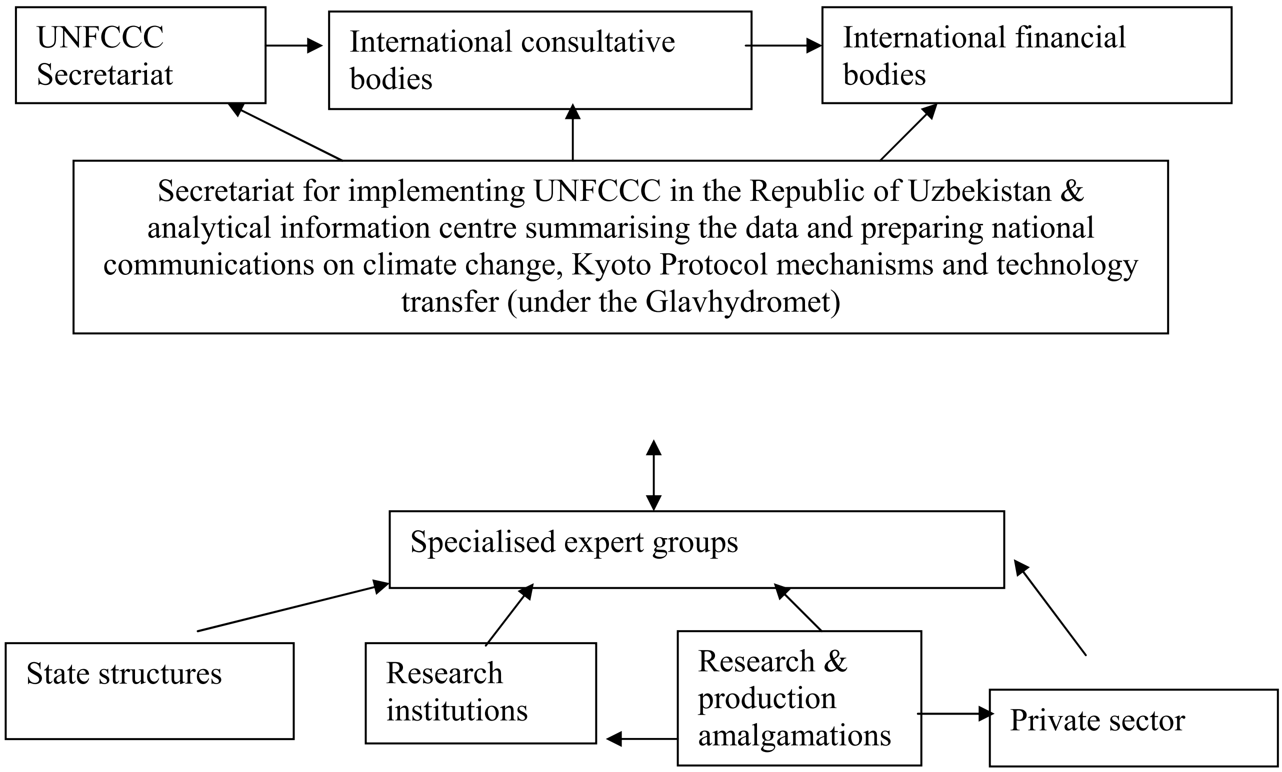
The scheme of co-ordination of national implementing agencies and their collaboration with international institutions is presented in Fig. 1.8.

In the course of implementation of the UNDP/GEF Project ‘Uzbekistan: Country Study on Climate Change, Phase 2’ teams of national experts have been formed to identify priority requirements of economic sectors in Uzbekistan aiming to reduce GHG emission and mitigate the negative impact of climate change as well as to analyse climatic vulnerability and design interventions of adaptation to climate change. One of the tasks addressed by the experts was to look for solutions of specific sector problems related to technology transfer. National expert teams were comprised of leading professionals from various sectors and departments well versed in the issues of technological modernisation and energy conservation in electric power engineering, oil and gas sector, construction materials industry, municipal thermal power engineering, forestry and agriculture as well as research institutions working in the areas of climate studies, hydrology, agro-climatology and environmental pollution monitoring.

Thus, implementation of the Project “Uzbekistan: Country Study on Climate Change, Phase 2’ helped improve the qualifications of national experts in addition to available experts on GHG inventory, adaptation interventions and mitigation of the impact of climate change.

It should be noted that the development of the institutional structure is largely determined by acceleration of technology transfer under the UNFCCC and the Kyoto Protocol. This is explained by the fact that the development of the logistical capacity in technology transfer is viewed in Uzbekistan within the context of establishment of a more flexible and constructive body for implementing the tasks and meeting commitments of both the Convention itself and the Kyoto Protocol. In order to meet these commitments and introduce better technologies a national interdepartmental body should be established, which will co-ordinate and manage the solution of these issues. Such a body may be established in the initial phase with the support of international financial institutions such as the GEF and the UNDP.

Fig. 1.8. Scheme of collaboration of national and international institutions



The establishment of such body will help co-ordinate activities of all line national agencies and promote an effective transfer, dissemination and application of environmentally friendly technologies.

1.3.2. Building Information Capacity

Although removal of information barriers is an important factor in the transfer and replication of more advanced technologies, at present Uzbekistan lacks a system of selection and dissemination of information on environmentally friendly technologies. This is only done within the framework of projects on climate change. The leading role in it belongs to Glavhydromet, which has access to international climatic and technological databases via the Internet and other means of communication. Besides that, it has close contacts with relevant governmental, research and engineering agencies in this area.

At the same time, higher public awareness of energy conservation policies using information systems and electronic mass media may have a significant effect on energy conservation in the country.

In order to build the capacity for technology information dissemination in Uzbekistan the establishment of well developed information systems and their connection to regional and international networks through specialised agencies and information companies is required. Equally important is to raise public awareness of climate change issues, sustainable use of fuel and energy resources, and a wider use of renewable energy sources.

1.3.3. Human Capacity Development

The transfer of many types of technology requires high qualifications from a wide range of managers as well as engineering and production specialists. They should have the correct idea of the national economic and environmental conditions, be able to assess technological requirements, know the possibilities and peculiarities of technology transfer, and be able to arrange exchange of the required data among national producers and international donors.

Unfortunately, most city and provincial khokimiyats lack skilled experts specialising in climate change and technology transfer. In the course of making an inventory and preparing the First National Communication as well as implementing the energy efficiency project in municipal heat supply, a number of training workshops and courses on various aspects of climate change, assessment of vulnerability of natural climatic resources and economic peculiarities of environmental projects were conducted, which were attended by young experts from various public institutions. However, upon project implementation the expert teams are usually disbanded. Apart from that, skilled professionals tend to leave their positions in the public sector for private companies because of low salaries. For this reason human capacity development in Uzbekistan encounters certain difficulties.

Thus, targeted activities aiming to develop the human capacity, improve the educational system, build the research and technical capacity of educational establishments, improve their curricula and promote regional and international co-operation are of high priority in the Republic of Uzbekistan.

1.3.4. Database on Technologies and Technological Requirements

A portfolio of possible projects has been formed in Uzbekistan to be implemented within the framework of the Clean Development and/or Joint Implementation Mechanisms. The database contains a brief description of each project, the required investment amount, the volume of reduction of the carbon dioxide and methane emissions, implementation periods, and specific capital investment per unit of emission reduced as a result of project implementation. Data on the projects also contain such economic parameters as project cost recovery period, the net present value and internal rates of return. Project description also contains engineering characteristics of solutions and technology owners. There are also the data on energy efficiency and possibility of project replication.

At present the database contains 40 project proposals in various sectors of national economy, which can reduce the total GHG emission by approximately 10 per cent. The list of projects is presented in Annex 1 to the present Report. Its creation will facilitate the dialogue with possible foreign investors and promote technology transfer.

1.4. Priority Projects Development and Management

1.4.1. Technological Proposals on Reducing Greenhouse Gas Emission. Selection Criteria and Computation Peculiarities

The studies have permitted to identify the main economic sectors and specific technologies to be transferred. These are electric power engineering (including renewable energy sources), oil and gas industry, chemical industry, construction materials industry, chemical industry and municipal economy. Besides that, proposals on the rehabilitation of woodlands and changes in land tenure technology in agriculture have been reviewed.

Table 1.20. Main economic indicators of technology transfer projects

№	Technology name	Capital investments (000 USD)	Annual emission reduction (000 tons)	Technology functioning period	Emission reduction by end of functioning period	Specific cost*) of emission reduction ($/ton)
1.	Modernisation of Navoi SREPP including construction of steam-and-gas units with a total capacity of 350 Mw & a calorific capacity of 150 Gcal/hour	232000	751	25	18775	12,36
2.	Modernisation of Tashkent SREPP including construction of steam-and-gas units with a total capacity of 370 Mw	221000	710	25	17750	12,45
3.	Construction of a steam-and-gas unit with a waste-heat boiler at Tashkent PP	22000	175	25	4375	5,03
4.	Modernisation of Bukharenergomarkaz open-end joint-sock company including construction of a gas-turbine unit with a capacity of 62 Mw	40000	162	25	4050	9,88
5.	Modernisation of Mubarek PP including construction of gas-turbine unit & waste-heat boilers	98900	362	25	9050	10,93
6.	Construction of a power plant at Navoiazot PA	136600	343	20	6861	20
	Total combined electric and thermal energy generation	**750500**	**2503**		**60861**	**12,3**
7.	Construction of Pskem HEPP with a capacity of 404 Mw	420000	1000	50	50000	8,4
8.	Construction of wind-driven stations	6000	14	25	355	17
	Total renewable energy sources	**426000**	**1014**		**50355**	**8,46**
9.	Introduction of energy-saving complex based on the heat-expansion machine DGA-5000 at Talimarjan SREPP	2500	12.6	15	189	13,23
10.	Modernisation of boiler houses # 1 & # 2 at Mubarek GR	2500	52.6	20	1052	2,38
11.	Modernisation of carbamide production at Chirchikelectrokhimprom plant	59660	127	20	2531	23,57
12.	Modernisation of carbamide production at ‘Azot’ PA in Ferghana	71000	138	20	2763	25,7
13.	Construction of a new ammonia unit at Chirchikelectrokhimprom plant	263560	205	20	4099	64,3
14.	Modernisation of a large-capacity ammonia unit at ‘Azot’ PA in Ferghana	25000	357	15	5353	4,67
15.	Modernisation of a large-capacity ammonia unit at Chirchikelectrokhimprom	25000	357	15	5353	4,67
16.	Construction of a new carbamide-producing shop at Navoiazot PA	71000	220	20	4399	16,14
17.	Modernisation of Bekabadcement JSC including conversion of the technological line from ‘wet’ to ‘dry’ cement production mode	84400	193	50	9650	8,75
18.	Modernisation of Akhangarancement JSC including conversion of the technological line from ‘wet’ to ‘dry’ cement production mode	87200	245	50	12243	7,12
19.	Modernisation of Kuwasaicement JSC including conversion of the technological line from ‘wet’ to ‘dry’ cement production mode	87200	179	50	8967	9,72

	Total increase in energy efficiency of production	**779020**	**2086**		**56600**	**13,76**
20.	Modernisation of the flare system in head facilities at Shurtanneftegaz OGRF	59534	474	20	9472	6,29
21.	Modernisation of the flare system at Mubarek GR	60000	497	20	9936	6,04
22.	Modernisation of compressor stations KC-0 in Mubarek	63810	111	25	2773	23,01
23.	Modernisation of compressor stations at head facilities in Gazli	100000	154	40	6173	16,2
24.	Reduction of natural gas leaks at KC-2 & KC-3 compressor stations	3800	641	40	25637	0,15
25.	Reduction of natural gas losses in supply lines of gas mains	64000	147	40	5880	10,88
	Total reduction of gas leaks	**351144**	**2024**		**59871**	**5,87**
26.	Utilisation of accompanying gases from Kokdumalak oil & gas condensate deposit at Mubarekneftegaz OGRF	82003	1135	30	34056	2,41
27.	Establishment of tertiary treatment of waste gases by the Scott method at Mubarek GR	28318	148	30	4442	6,38
28.	Assembly of a system of automatic control of waste gases composition & load, & sulpheretted hydrogen & oxygen ratio at Mubarek GR (sulphur production by KLAUS 2nd phase method)	848	60	20	1193	0,71
29.	Establishment of tertiary treatment of waste gases by the catalyst cold layer adsorption method (CLA) at Mubarek GR	2287	79	30	2357	0,97
30.	Gas fractionating unit (GFU) at Ferghana OR (fractionation of a mixture of light saturated hydrocarbons)	76782	208	30	6252	12,28
31.	2nd stage of facility for sulphur production by direct oxidation method at Mubarek GR	870	26	20	529	1,64
32.	Modernisation of glassware production at Kwartz JSC	6000	15	25	385	15,58
	Total increase in production efficiency	**197108**	**1672**		**49215**	**4,01**
33.	Use of domestic wastes as low-calorie fuel (wastes-incinerator in Samarkand City)	45000	128,1	25	3203	14
34.	Technology of generating electric & thermal energy based on biological gas from excessive active silt at sewage treatment facilities in Tashkent City	8000	19	25	478	16,8
	Total utilisation of wastes	**53000**	**147**		**3681**	**14,4**
	Grand total for all projects	**2556772**	**9446**		**280583**	**9,1**

*) Ratio of required capital investments to the amount of emission reduction during the entire period of project implementation.

The investment proposals meeting the following main criteria have been selected:

- availability of proven (calculable) reserve of GHG emission reduction;
- conformity with the aims of national economic development and specific project objectives;
- availability of required technical and economic data;
- promotion in the transfer of new technologies.

For each of the selected projects an assessment of economic efficiency has been conducted based on the method ‘Discount Model of Cash Flow’, for which purpose a reserve of GHG emission reduction and the required investment volume have been determined.

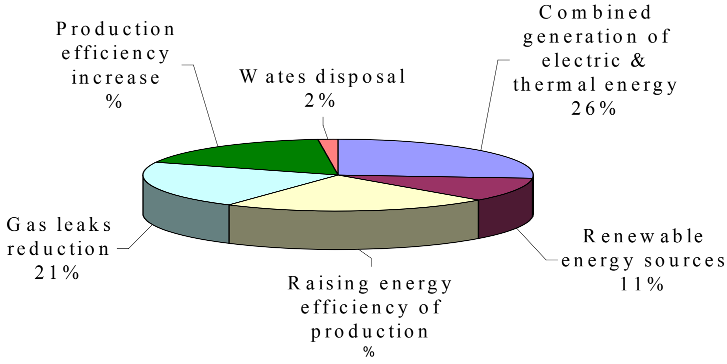
The base line of the projects was computed considering the emission that could have occurred without the implementation of the project providing for emission reduction. Special attention was focussed on really reducing emission volumes as a result of project implementation, and not redistributing them among other sectors or other territories. The main data on the selected projects are presented in Table 1.20.

The total technical reserve of GHG emission reduction of the selected projects is assessed at 9.4 million tons annually (280.6 million tons during the entire period of project implementation).

The most effective from the viewpoint of specific costs on the GHG emission reduction is the project on cutting natural gas leaks at compressor stations. Total specific costs of reducing a unit of emission do not exceed 10 $/ton.

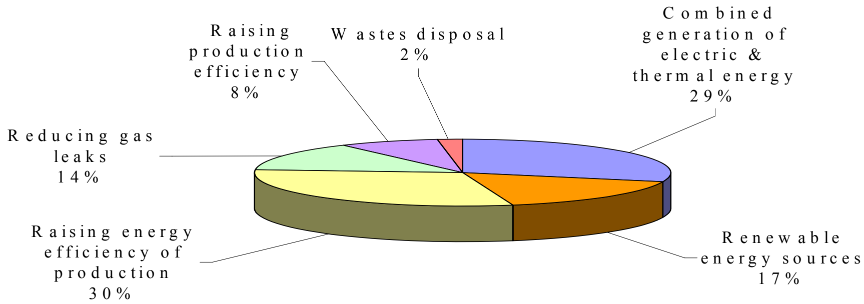
The structure of emission reduction by main categories is presented in Fig. 1.9.

Fig. 1.9. Reserve of GHG emission reduction in a normal year



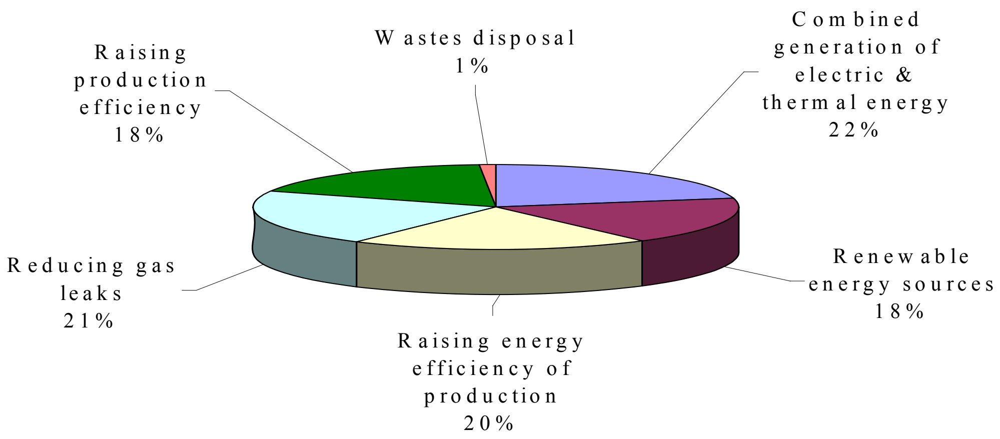
Total investments in the implementation of the proposed projects (see Fig. 1.10) amount to US $3,556.8 million, and most of them, US $2,503.8 million, fall into the category of power engineering.

Fig. 1.10. Total investments by the main categories of proposed projects



A comparison of the structure of the required investment volumes by main categories of the proposed projects and corresponding GHG emission reduction amount (Fig. 1.11) has shown that most preferable from the viewpoint of cutting GHG emission reduction are investments in projects aiming to raise production efficiency and cut gas leaks because they permit to secure a considerable GHG emission reduction (18 to 21 per cent of all emission respectively) with insignificant investment volumes (8 to 14 per cent of investments required for the implementation of all projects respectively).

Fig. 1.12. GHG emission reduction during the entire period of project implementation



1.4.2. Economic Efficiency of Investment Projects and Possibility of Their Transfer

In the course of project formulation an assessment of their financial and economic efficiency was undertaken. The findings of the financial and economic analysis are presented in Annex 2.

According to estimates, 32 per cent of all projects have a positive net present value (NPV) of all annual capital investments for a period of 15 years, and their internal rate of return (IRR) for the same period is higher than the accepted discount rate (10 per cent). This is mostly connected with price factors because the current prices on energy resources, especially on natural gas, are more than twice lower for domestic consumers than the export and import prices in the region.

A considerable improvement of financial and economic indicators of the projects may also be obtained in the event of application of Clean Development or Joint Implementation Mechanisms.

This testifies to the fact that support of international and foreign financial institutions as well as the state will be required to implement projects on GHG emission reduction under the current conditions prevailing in Uzbekistan.

Implementation of the proposed projects will promote the achievement of results in the areas of environmental pollution reduction, infrastructure modernisation, and technology transfer and introduction.

1.4.3. Investment Climate and Technology Market

A stable socio-political situation and availability of a cheap social and production infrastructure create favourable conditions for capital investments in Uzbekistan.

The macroeconomic stability and the economic growth of basic economic sectors have been secured in the country. The Gross Domestic Product has reached 3,194.5 billion soums in current prices, and its actual volume has increased by 4 per cent against 1999. The amount of investments in economy from all funding sources has risen by one per cent. The volume of export has increased and a positive foreign trade turnover balance has been achieved. The prevalence of exports over imports has reached 110.8 per cent. The rates and scale of denationalisation and privatisation have considerably risen. In 2000, 374 state-owned facilities have been privatised. Returns from denationalisation and privatisation have increased 1.6 times against 1999.

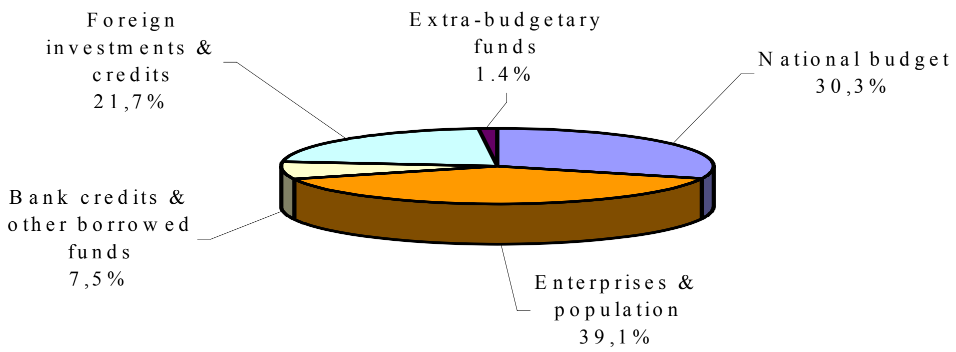
Positive developments have taken place in small and medium-scale businesses and private enterprise. The number of small, medium and micro businesses has increased by 14.5 per cent and reached 183,000 in the course of a year.

The non-state economic sector accounts for 70.2 per cent of the gross domestic product; 65.4 per cent of industrial output, 99 per cent of gross agricultural output and 81.3 per cent of construction works.

The 2000 investment programme has been translated into life. Funds invested in fixed assets from all funding sources reached 696.3 billion soums. Of this amount 386.5 billion soums or 55.5 per cent of all delivered investments were spent on the development of productive economic sectors.

Fig. 1.12 presents the structure of investments in fixed assets by funding sources in 2000.

Fig. 1.12. Structure of investments in fixed assets by funding sources in 2000



In 2000 foreign investments and credits constituted 21.7 per cent of total investments in the economy of Uzbekistan.

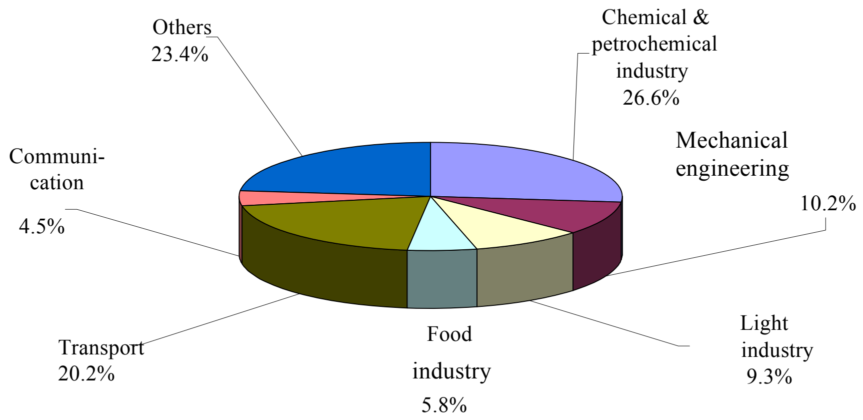
By the beginning of 2001, 3,445 enterprises with foreign investments had been registered in Uzbekistan. The volume of production, works and services of joint ventures reached 386.7 billion soums and surpassed the 1999 level by 45 per cent. Enterprises with foreign investments exported US $451.6 million worth of goods (121.6 per cent against 1999). Their share of all export operations in the country constituted 13.8 per cent.

Enterprises established jointly with major companies from the USA, Great Britain, Russia, Turkey and other countries are operating successfully. Among them are 'Zeravshan-Newmont' (gold mining), UzBAT (tobacco processing), UzDAEWOauto (automobile industry), 'Alcatel' and 'UzDUNrobita' (telecommunication systems) and other enterprises. In 2000 'Hodas-TAPO' JV producing non-metallic pipes and 'Uzsmatana'Santekhnika' JV producing hot and cold water meters were put into operation. Start-up and adjustment activities have begun at the Shurtan gas and chemical works.

Fig. 1.13 illustrates the structure of delivery of foreign investments and credits by economic sectors as percentage of the total amount of foreign investments and credits.

In Uzbekistan there is a sufficiently well developed market infrastructure (banks, insurance companies, commodity exchanges) and a communications system with a ramified transportation system permitting to engage in both internal and external haulage, and not only to the neighbouring but also to remote countries.

Fig. 1.13. Structure of delivery of foreign investments and credits by economic sectors



Uzbekistan has a large labour force constituting 72 per cent of the population. The educational level permits to develop science-intensive and high technology production. Availability of cheap and skilled labour force secures low labour costs of business establishment and management.

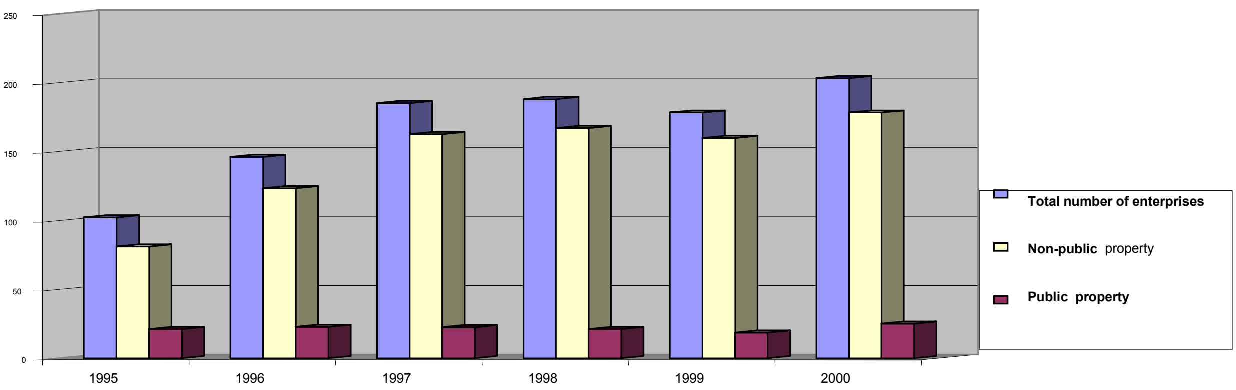
Since independence much has been done in Uzbekistan to establish a legal and regulatory framework meeting international standards and rules. This permits enterprises and agencies to operate independently in the external market, encourages the establishment of new economic structures and provides reliable guarantees to foreign investors. Laws, Presidential edicts and government decrees have been passed permitting to address strategic issues in reforming the country's economy including the establishment of an enabling investment environment. There is a legal framework in the country permitting to attract foreign investments, regulating and encouraging foreign investors' activity, outlining the concept of public regulation of various foreign economic activities including foreign investments, securing protection of the rights, interests and property of foreign economic actors regardless of their form of ownership in conformity with international law, and regulating freedom of movement of foreign investors. Especially favourable investment conditions are granted to those foreign partners, which invest capitals in the development of strategic sectors of the national economy of Uzbekistan and capital-intensive enterprises using high technologies. According to legal acts, foreign investors are granted 25-year concessions to operate oil and gas fields, and in doing so they have the right of ownership of the part of extracted raw materials defined in foundation documents or concession agreements, which they may take out of the country and process on a tolling basis. Uzbek enterprises and agencies supplying the required materials, doing work and rendering services to foreign companies engaged in oil and gas exploration are exempted from the value-added tax.

The above factors create an enabling economic environment for attracting foreign investments and implementing both short- and long-term investment projects, and a possibility of transfer of highly effective modern technologies into priority sectors of the country's economy.

1.4.4. Role of the Private Sector in Technology Transfer

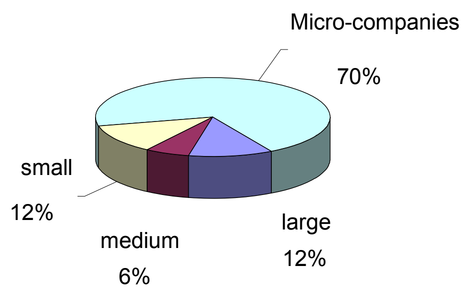
The most important instrument in raising production efficiency, improving management, promoting competition and involving foreign investments is the liquidation of monopoly of public ownership. In 2000, 87.7 per cent of legal entities in Uzbekistan were no longer state property. Of the total number of registered legal entities 37.9 per cent are private companies, 25.3 per cent are peasant and leased farms, 3.9 per cent are joint stock companies, 6.7 per cent are limited liability companies, and 1.4 per cent are enterprises with foreign investments. Changes in the ownership of legal entities from 1955 through 2000 are illustrated in Fig. 1.14.

Fig. 1.14. Changes in the ownership of legal entities from 1995 through 2000



Changes in the share of medium-scale, small and micro companies from 1997 through 2000 are illustrated in Fig. 1.15.

Fig.1.15. Changes in the share of medium-scale, small and micro companies from 1997 through 2000



Small and medium-scale businesses constitute a significant share in the country. In 2001 there are149,300 medium-scale, small and micro companies. Of this number 6,400 are medium-scale, 20,400 are small and 122,500 are micro companies. The largest number of medium-scale and small businesses (including micro companies) are operating in Tashkent City (11.6 per cent of the total number of medium-scale and small businesses) as well as in Samarkand (10.9 per cent) and Andijan (10.8 per cent) provinces.

The current phase in market-oriented reforms aims to intensify denationalisation and privatisation. Decree # 119 of the Cabinet of Ministers of the Republic of Uzbekistan 'On

Furthering Denationalisation and Privatisation of Enterprises with the Involvement of Foreign Investments in 2001-2002' of March 9, 2001 lists enterprises undergoing corporatisation according to individual schemes with the participation of foreign investors. Among them are major enterprises of 'Uzbekneftegaz' NHC, some of the SREPPs and HPs of 'Uzbekenergo' SJSC and enterprises of 'Uzkhimprom' Association. The process of privatisation and restructuring of commercial banks has encompassed such banks as 'Asaka', Uzpromstroibank, Pahta-Bank, the National Bank for Foreign Economic Activity and other commercial banks having a public share in their charter capitals.

Systematic activity of the Government of Uzbekistan in denationalisation and privatisation promotes the growth of the non-public sector of economy, which is bound to raise its role in the transfer of new technologies including those that permit to reduce GHG emission.

1.4.5. Role of Legislation in Technology Transfer

The Parliament of the Republic of Uzbekistan has enacted over 100 laws and decrees on environmental protection and use of natural resources and energy including these:

- on Sustainable Use of Energy,
- on Nature Protection,
- on Water and Water Use,
- on the Protection of Atmospheric Air,
- on Arranging the Formulation of the Programme for the Development of Computer and Information Technologies for 2001-2005 and Provision of Wide Access to the Internet International Information Systems,
- on Interventions to Liberalise Currency Market,
- on Interventions to Encourage the Development of Private Enterprise as well as Small and Medium-Scale Businesses,
- on Investing Activity,
- on Leasing,
- on Environmental Assessment,
- on Enterprise and Guarantees of Entrepreneurial Activity,
- on Incentives and Privileges Granted to Enterprises Involving Foreign Investments,
- on Interventions to Encourage Implementation of Investment Project,
- the Land Code,
- on Forests,
- on Free Economic Laws,
- on Copyright and Accompanying Rights,
- on Guarantees and Measures of Protecting Foreign Investors Rights,
- on Furthering Denationalisation and Privatisation of Enterprises with the Involvement of Foreign Investors in 2001-2002,
- on Implementing Interventions Related to Privatisation of Banks in the Republic of Uzbekistan within the Framework of the Financial Sector Institutional Development Project with the Participation of the International Bank for Reconstruction and Development, etc.

Interventions aiming to reform macroeconomic policies, reorganise the energy market and the pricing structure, strengthen the commercial and legal framework of investments, and formulate national strategies of energy conservation and introduction of effective technologies into economic sectors and the social sector are required in future.

1.4.6. Identification of Barriers to Introducing New Technologies

The transfer of technologies in Uzbekistan may encounter logistical, legal, social, psychological, economic, financial, technological and information barriers characterising a limited capability of the economic mechanism to assimilate innovations. This will require their additional analysis in each specific case.

At the same time, Uzbekistan has vast potentialities for taking economically effective interventions to mitigate the impact of climate change.

Barriers of a general nature identified in the course of analysis are listed in Table 1.20.

Table 1.20. Barriers to technology transfer and ways of removing them

#	Barriers	Possible solutions
1	**Economic situation:**	
	• limited public resources for purchasing equipment abroad	• extension of grants & easy credits; expansion of operational programmes of multilateral financing institutions
	• lack of national currency conversion	• improvement of the economic situation in the country; acquisition of government permissions on currency operations
	• state subsidies to energy consumption	• inclusion of the actual cost of energy resources into the national financial turnover
	• low paying capacity of enterprises & population	• raising public awareness and introducing energy conservation interventions
	• non-involvement of national banks in technology transfer	• involvement of national banks in project formulation and implementation
2	**Peculiarities of the fuel and energy sector:**	
	• lack of national energy consumption standards	• formulation of standards and norms of energy resources consumption and technological equipment efficiency
	• lack of domestic production of power engineering equipment	• development of joint production enterprises
	• low prices on organic fuel	• formulation of pricing policies reflecting the actual costs of energy supply; introduction of taxes on GHG emission
3	**Lack of awareness:**	
	• lack of access to technological information	• development of a system of specialised information services
	• low public awareness of the necessity of energy conservation and emission reduction	• intensification of public awareness interventions related to climate change issues as well as mitigation of the impact of and adaptation to climate change
	• lack of information among investors on the potential technology market in Uzbekistan	• in-depth assessment of the country's technological requirements and activities within the framework of the projects selected for specific investors; development of consulting services in entrepreneurial activity
4	**Lack of skilled professionals in energy conservation and efficiency**	• targeted development of human capacity and training of specialists for the public and private sectors

2. Study of Climate Change Impact on the Environment and Economic Sectors of Uzbekistan

2.1. The Impact of Climate Change on Water Resources in Conditions of Their Intensive Use

2.1.1. Comprehensive Approach to Assessing Vulnerability of Water Resources Considering Irrigated Farming Requirements

Current studies of water resources, especially as regards future water probability forecasts, are closely connected with the issue of a steadily increasing impact of economic activity on the river run-off, the global climate and moisture turnover.

The territory of Uzbekistan is characterised by an extremely uneven distribution of water bodies and rivers. There are very few waterways in the vast planes, and rivers receive no tributaries on their way from the mountain foothills to the estuary. Different nature of the run-off processes in the mountains and in the plains has led to the division of the territory into the ***upper watersheds*** situated in uplands and ***water dispersal area*** where the run-off is withdrawn for irrigation purposes and evaporates.

At present water resources of rivers in the Aral Sea Basin are practically entirely regulated and distributed among water users. At the same time, the share of water resources formed in the territory of Uzbekistan constitutes only 10 per cent of the total river run-off in Central Asia. According to interstate agreements Uzbekistan receives from 43 to 52 km^3 of water annually. ***The main consumer of water resources is irrigated farming, which uses over 90 per cent of the available water.***

To assess changes in the river water content under the pact of climate change a mathematical model of river run-off formation developed at the Central Asian Research Hydro-meteorological Institute has been applied. The model permits to take into account the main regularities of surface water formation under the impact of climatic factors (air temperature, atmospheric precipitation, evaporation) as well as the quality and structure of the available information on the existing run-off series and regional climatic scenarios, and also to consider the human-induced impact on the run-off.

To assess the vulnerability of water resources and design adaptation interventions with due regard for the existing human-induced impact and possible scenarios of irrigated farming development various options of development of the situation in the country have been reviewed.

Possible scenarios of irrigated farming development. A steady population growth in Uzbekistan increases the number of water users and water consumers, especially in agriculture, which increases withdrawal of the river run-off and reduces the available water resources.

At present lack of water resources has resulted in stabilisation of the area of irrigated farming in the country. An analysis of population growth rates (from 8.3 million in 1960 to 31-34 million in 2030) has shown that per capita availability of irrigated arable lands is steadily decreasing, from 0.32 ha in 1960 to 0.18 ha in 1999 and 0.14-0.13 ha in 2030 (estimate).

There exist different approaches to the use of water resources in the Central Asian region, which gives rise to a number of critical situations related to their use. In the upper reaches of rivers lying in the territories of Kirghizia and Tajikistan that are a source of most regional water resources prevail the interests of water consumers using the power engineering capacity of rivers. Most water consumption takes place in the winter period while for the irrigated lands of Uzbekistan lying downstream water is required in the spring and summer period. In conditions of present-day acute water deficit as well as pollution and mineralisation of surface and ground water even a small reduction in the amount of water resources poses a serious threat.

The available reserves of water resources boil down to regeneration of waste and drainage water for their subsequent re-use, desalination of saline water and use of undeveloped groundwater resources. Water demand management and reduction of losses in agriculture harbour considerable reserves. Estimates of the required area of irrigated lands in the period up to 2050 may be presented under the three scenarios of population growth with due consideration for the prospects of irrigated farming and livestock development (see Table 2.1).

Table 2.1. Demand of irrigated farming for water (km^3) in Uzbekistan under various scenarios of population growth

Scenario	**Years**					
	2000	**2010**	**2020**	**2030**	**2040**	**2050**
Accelerated (up to 55 million)	53,2	52,4	51,6	51,0	49,8	48,6
Medium (up to 45 million)	53,3	52,5	52,0	51,8	51,0	50,4
Slow (up to 37 million)	53,3	52,7	52,4	52,5	52,1	52,1

In the course of the assessment the area of irrigated land under cotton did not change while the areas under other farm crop varied at various times. ***It was assumed that by 2030 Uzbekistan would reach the level of industrialised countries in the yields of most farm crops. Water resources were assumed as equal to the present-day level. Growth in water demand is supposed to be compensated by the introduction of water saving techniques.***

The results of assessment of the required area of irrigated lands and specific water withdrawal per unit of irrigated area given the observance of the above conditions are presented in Fig. 2.1 and 2.2.

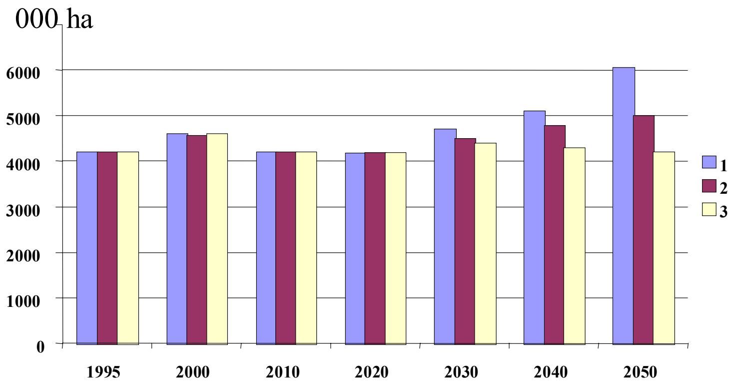


Fig. 2.1. Required area of irrigated lands under various scenarios of population growth.

1 – **scenario of accelerated population growth up to 55 million by 2050**
2 – **scenario of medium-scale population growth up to 45 million by 2050**
3 –scenario of slow population growth up to 37 million by 2050

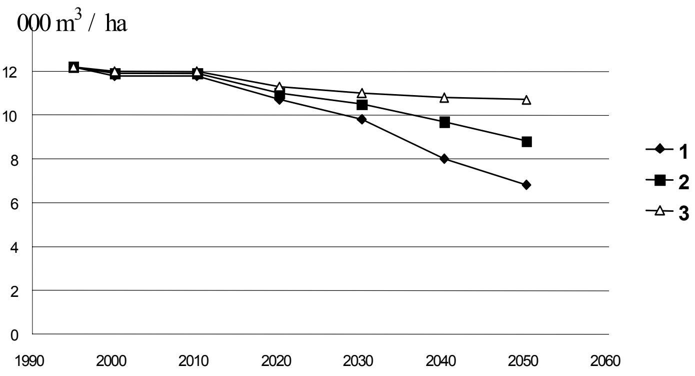


Fig.2.2. Specific water withdrawal for irrigation under the different scenarios of population growth.

1 – high, **2** – medium, **3** – low.

Noting the priority nature of water conservation interventions in irrigated farming for a sustainable development of states it should be remembered that they ***do not increase the amount***

of water resources in the Aral Sea Basin in general. It should be taken into consideration that with the introduction of water conservation technologies and reduction of return flow the cost of each cubic metre of water will increase as compared to the present.

The outputs of optimisation computations show that the limited available water resources may meet the increasing requirements of the national economy in future. However, they do not take into considerable the influence of already existing and possible human-induced climate changes and environmental problems such as the global warming, degradation of mountain glaciers and groundwater resources, river pollution and silting, etc.

2.1.2. Assessment of Sensitivity of River Watershed to Natural and *Human-Induced Changes in Climatic Parameters*

To assess the impact of the expected warming on water resources, artificial scenarios of the most probable future climatic situation were used.

Regional rivers react to the warming differently, which is primarily explained by differences in their origin. The run-off in rivers fed by snow decreases faster with the rise in temperature. Rivers with a considerable contribution of ice in their run-off are more 'inert' in this respect because a rise in temperature intensifies the melting of high-mountain snow and glaciers thus creating certain compensatory conditions for their run-off. However, due to the continuing degradation of glaciers, which will intensify as the temperature rises, a decrease in the run-off, and possibly a more intensive one, will take place there in future as well.

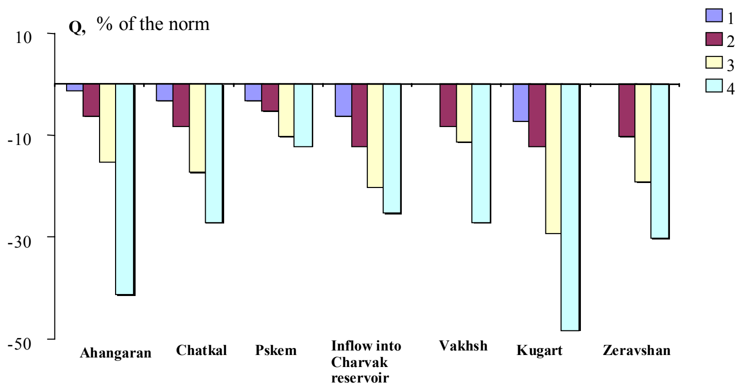


Fig. 2.3. Changes in vegetation flow of indicator rivers with changes in air temperature.

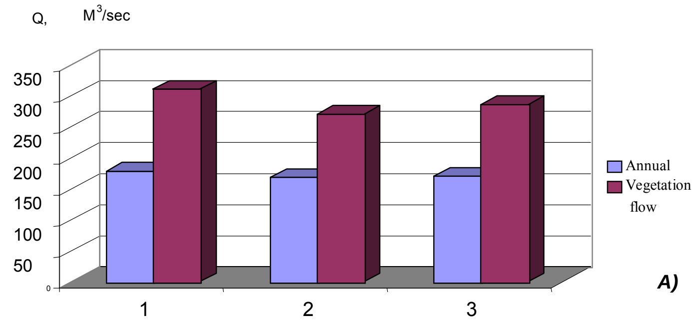
1 – T+1° C
2 – T+2° C
3 – T+3° C
4 – T+4° C

Fig.2.3 presents changes in the run-off of some indicator rivers with various types of feeding in case of an artificially set climatic situation, for instance, in case of a rise in temperature by 1, 2, 3 and 4º C.

Fig. 2.4 presents a change in the annual and vegetation inflow into the Charvak reservoir (Syrdarya River basin) and the Nurek reservoir (Amudarya River basin) as an integral feature of the run-off.

It is common knowledge that cases when water withdrawal exceeds 20 per cent of the total volume of renewable water resources are already classified as water shortage limiting a country's sustainable development. Water withdrawal in the amount of 40 per cent and more is regarded as a high pressure.

The greater part of the Aral Sea Basin is in such a phase of human-induced impact on the river run-off when water withdrawal has achieved 60 to 100 per cent. The compensatory reserves of the basin have practically been exhausted, and water consumption increase is accompanied by a decreasing river run-off both in terms of time and length of flow.



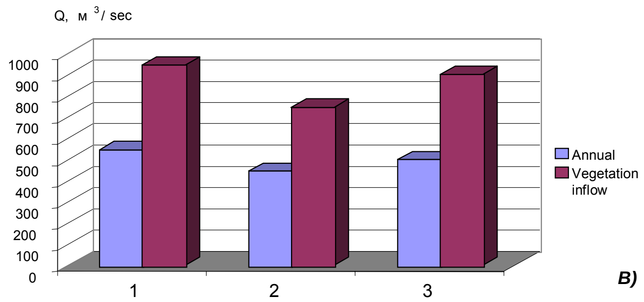


Fig. 2.4. Changes in water inflow into Charvak (A) and Nurek (B) reservoirs in case of increase in air temperature
1 – T°C - norm
2 – T+2° C - October - September
3 – T+2° C - October – March

An indicator of the human-induced pressure on water resources of Central Asian rivers is the flow withdrawal rate computed as a ratio of the total water withdrawal to the inflow from the upper watersheds. It depends on the river water content, the annual water content and the extent of water consumption in the national economy. The flow withdrawal rate increases from water abundant to shallow years, and in the event of an equal inflow from the upper watersheds it increases in each subsequent level of water management construction.

As water resources are exhausted (with the flow withdrawal rate higher than1) irrigation can only be developed by raising the efficiency of water resources consumption and changing the structure of flow use in favour of a sharp reduction of unproductive losses.

Since a rise in temperature has a negative impact on water resources and leads to their decrease, tensions in the area of water use and water consumption are likely to rise.

2.1.3. Selecting and Adapting Run-off Changes Assessment Method Considering Human-Induced Impact and Information Capacity

The assessment of the impact of natural and human-induced factors on the river run-off is based on the method of identifying the ***integral effect*** of a number of factors such as atmospheric precipitation and evaporation; air and soil temperature and humidity; soil properties; vegetation; geological structure and terrain, crop farming, water withdrawal and discharge into riverbeds, run-off regulation, etc. Considering the availability of two clearly defined watersheds and water distribution areas, total losses calculated on the basis of the difference between the river run-off in the upper watersheds and in its utilisation area may be used as an indicator of the integral effect of irrigation. This difference includes evaporation from irrigated and non-irrigated lands, evaporation from water reservoir surfaces, changes in water reserves in soil and water reservoirs, non-return industrial and municipal water consumption, transfer of a part of run-off into other basins and water discharge into land-locked depressions.

In the assessment of the future human-induced impact on the run-off of rivers in the Aral Sea Basin the choice of the computation method is determined by the available input data. An integrated methodology of computing future human-induced changes in the river run-off includes a simultaneous use of the following methods. Statistical methods based on the studies of multi-annual variations of run-off properties jointly with changes in the development of the main types of economic activity in the basins.

Methods based on the water balance permit to reveal the genetic essence of the processes taking place in a territory under the impact of a number of water management interventions. Solution of water balance equations for a given territory in various phases of water management construction (different irrigated areas, crop patterns, irrigation techniques and efficiency of irrigation systems, etc.) is the most correct method of assessing run-off changes under the impact of land reclamation by irrigation.

Mathematical modelling permits to quantify the impact of various combinations of natural and human-induced factors, and compute the future hydrological regime and the water balance in the watersheds in the event of different scenarios of economic development of a territory. The outputs depend not only on the reliability of input data but also on the completeness and substantiation of computation equations, parameters and rates.

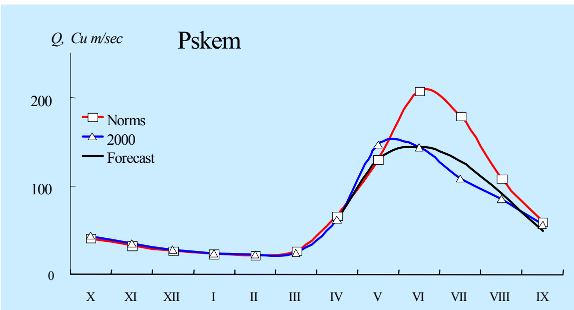
2.1.4. Perspective Assessment of River Run-off in the Aral Sea Basin in Conditions of Climate Change

A comprehensive assessment is based on mathematical models of formation and use of water resources in a river basin. The model has permitted to compute the run-off at various sites and under various combinations of meteorological conditions and the economic activity in the basin.The initial mode of model functioning is the computation of natural run-off hydrographs, for which purpose the actual hydro-meteorological situation was used.

Inclusion of various blocs into the model takes into consideration the economic activity factors such as run-off regulation and loss on evaporation by the existing water reservoirs and those under construction; irrigation; industrial, municipal and agricultural water supply; water arrival from other basins and withdrawal of a part of the run-off into other basins.

A detailed study is undertaken of the water balance elements of river basins, especially evaporation from various lands; losses in irrigation systems and in case of water use for various economic needs as well as a study of extremely dry years and already observed negative consequences (analogues method).

An analogue of the future warming may be a complex hydro-meteorological situation of 2000.



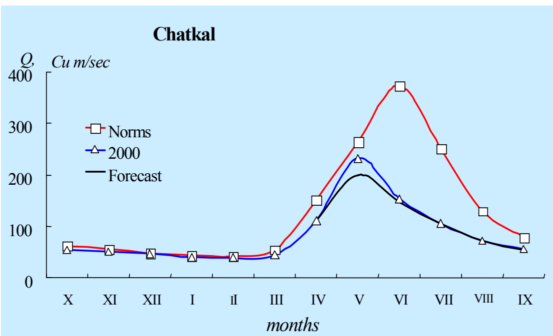


Fig. 2.5. Hydrographs of Pskem and Chatkal rivers.

Dryness in that year was caused by a shortage of precipitation in the period of run-off formation and high air temperature. To verify models based on precipitation and air temperature methods hydrographs of Chatkal and Pskem rivers for 2000 were computed.

Fig. 2.5 presents the actual hydrographs and those forecast on the basis on a model as compared to average multi-annual values.According to monitoring data of Glavhydromet of the Republic of Uzbekistan the average annual air temperature in the country in 2000 was higher than normal. That year and 1941 were the hottest ones during the entire monitoring period.An analysis of changes in annual precipitation amounts in Uzbekistan shows that 2000 was extremely dry.Changes in the run-off in the middle and lower reaches of the Amudarya Rive based on monitoring data since 1975 are presented in Fig. 2.6. Water withdrawal increases closer and in conditions of shallow water in 2000 the run-off at Samanbai site was practically equal to zero.

Fig. 2.27 presents multi-annual changes in the Aral Sea level and water inflow into the river delta (Kyzyljar site). In the past decade the Amudarya run-off failed to reach the Aral Sea three times and one of them was in 2000.

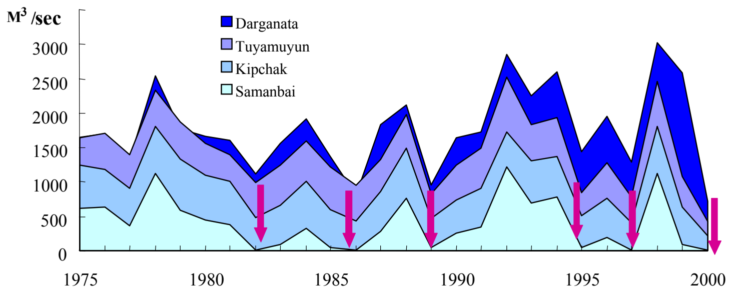


Fig. 2.6. Changes in run-off in the Amudarya lower reaches from 1975 through 2000.

The Aral Sea level continues to drop. In the summer of 2000 the level of the Larger Sea has dropped to 33 m, and in December it fell to 32.61 m. A study conducted by various methods has permitted to assess the impact of climate change on river basins and undertake an integral assessment of the run-off.

Thus, the results obtained have shown that none of the tested climatic scenarios reflecting the global warming provide for any increase in the Amudarya and Syrdarya river run-off. Moreover, a considerable decrease in run-off should be expected during vegetation periods.

An estimate of the future run-off in the main rivers of the Aral Sea Basin as a result of climate change has shown that the worst options harbour a possibility of a 15 to 20 per cent decrease in the Syrdarya River run-off and a 20 to 30 per cent decrease in the Amudarya River run-off as well as a reduction in snow and ice cover in the mountains.

In future a possible increase in the frequency of precipitation fallout and intensify of rainfall will lead to a growing number of rainfall floods, intensification of mudslides and soil erosion. Increasing evaporation will lead to higher water losses in irrigation areas and therefore higher irrigation norms.

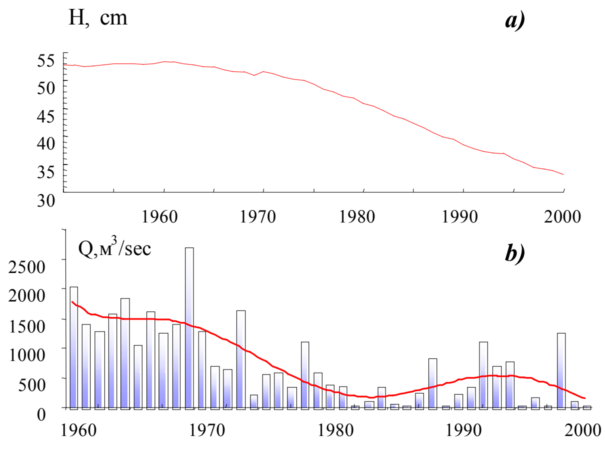


Fig. 2.7. **Multi-annual changes in the Aral Sea level (a) and water inflow into the Amudarya delta (b).**

A rise in temperature along with unchanged precipitation will lead to a shift in the period of spring floods on rivers, which will have a negative effect on agriculture and operation of waterworks. Under increasing human-induced pressure and run-off use for irrigation its development becomes possible only by raising efficiency of water resources use and sharply reducing unproductive losses.

2.1.5. Consequences and Risks, Interventions of Sustainable Use of Water Resources

- Climate change in case of a 1-2º C rise in temperature will lead to a lower water content in rivers predominantly fed by snow, and in the longer run to a sharp reduction of run-off in rivers fed by both snow and glaciers.
- An air temperature rise of 1-2º C will intensify the process of ice degradation. In 1957-180 glaciers in the Aral Sea river basins lost 115.5 km^3 of ice (approximately 104 km^3 of water), which constituted almost 20 per cent of the 1957 ice reserve. By 2000 another 14 per cent of the 1957 reserve were lost. By 2020 glaciers will lose at least another10 per cent of their initial volume.
- A 3-4º C rise in air temperature will result in the loss of all glaciers in the region. While in the initial period of the warming the melting of glaciers somehow compensates for a decrease in the run-off, it will be further followed by a disastrous fall in the river water content by 30 per cent and more.
- In case of a 3-4º C rise in air temperature water resources may decrease by 40 per cent of their current amount.
- A decrease of regional water resources by one third will sharply reduce the irrigation capacity of the water management system and have a direct impact on irrigated farming. Even at present only 48-50 per cent of water intake reaches the fields due to bad irrigation systems, irrigation techniques and watering technologies. A rise in air temperature even by 1-2º C will increase these losses (due to evaporation and filtration into the soil) by another 10 per cent.
- A shortage of water resources gave rise to the Aral Sea crisis. In the event of dryness further conservation and restoration of the Aral Sea will become unfeasible, at least with the help of the subcontinent's own water resources. Under the arising circumstances total water conservation in all economic sectors and especially in irrigated farming acquires utmost importance.

The existing regional issues of water use and water consumption aggravate the above problems (see Fig. 2.8). The increasing shortage of water resources necessitates new approaches to water availability in the interests of sustainable development of riparian states and the region at large, with orientation to an effective use of all available water resources (see Fig. 2.9).

The problem of water availability includes the following two main phases, one is securing a sustainable use and protection of water resources, and the other is securing their optimal use, reproduction, replenishment and protection.

The present-day use of water resources actually results in a complete distribution of river run-off among water users. The available reserves in water resources management are narrowed to regeneration of waste and drainage water for re-use as well as desalination of saline water and use of undeveloped groundwater reserves.

Water demand management harbours considerable reserves, especially in agriculture. A comprehensive assessment of future demand for water in irrigated farming given various scenarios of climate change and development of agriculture as well as consideration of the demographic factor should be undertaken for the formulation of a sustainable water use strategy.

Methods of sustainable water use should include a set of interventions mitigating the negative impact of climate change on water availability:

- Rehabilitation of old irrigation systems;
- Desalination and purification of drainage water;
- Search of untraditional ways of replenishing water resources;
- Application of semi-closed and closed water supply systems in industrial production;
- Introduction of latest technologies into crop farming.

Of major importance is preservation of the irrigation mode in the operation of water management systems. The current reorientation of the operation mode of water reservoirs in the Naryn River from irrigation to power engineering may reduce the irrigation capacity of the Syrdarya River in Uzbekistan by 1.5 to 2 km^3/year.

Sustainable use of water resources and provision of consumers with water with a sufficient extent of reliability is only possible in case of implementation of a large number of sophisticated water management interventions such as:

- Construction of hydro-schemes near dams;
- Regulation and re-distribution of the river run-off;
- Comprehensive reconstruction of irrigation systems;
- Implementation of a number of water protection interventions;
- Use of groundwater in considerably larger amounts;
- Better re-use of drainage water;
- Reduction of unproductive water discharge from rivers and irrigated lands;
- Reduction in run-off use outside of vegetation periods;
- Improvement of watering techniques thanks to effective irrigation technologies such as subsoil and drop irrigation.

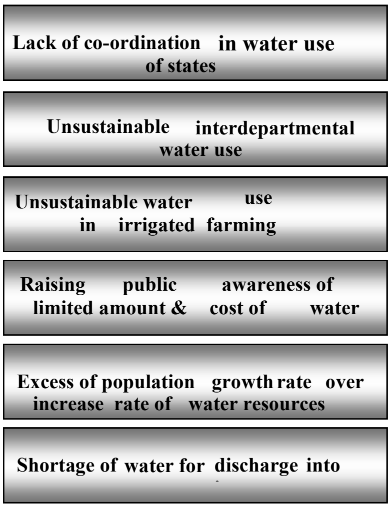


Fig. 2.8. Current problems of water availability in Uzbekistan, factors increasing vulnerability of water resources

In order to find additional reserves in water use and solutions to combating losses in irrigation systems studies should be undertaken in the following areas:

- **Formulation of water consumption norms considering natural peculiarities, reclamation regime and watering technique;**
- **elaboration of prospects in changes of return water resources throughout the region considering improvement of irrigation systems;**
- **study of water losses in systems of different engineering levels and formulation of recommendations on their reduction for various parts of the region;**
- **design of economic anti-filtration coating of canals;**
- **zoning of watering techniques throughout the region;**
- **design of subsoil irrigation systems;**
- **study of methods of raising biological productivity;**
- **selection of salt-resistant crops to expand the range of saline water use in irrigation.**

In conditions of exhaustion of river water resources on the subcontinent sustainable use of groundwater resources has become vital. Submerged irrigation is effective in cultivating water-loving crops with deep root systems.

Besides that, in case of counter-regulation of Syrdarya and Amudarya water management systems from power-engineering into irrigation regimes a need will arise to use underground tanks, therefore underground storage systems should be established in the Zeravshan, Ferghana and Surkhandarya oases.

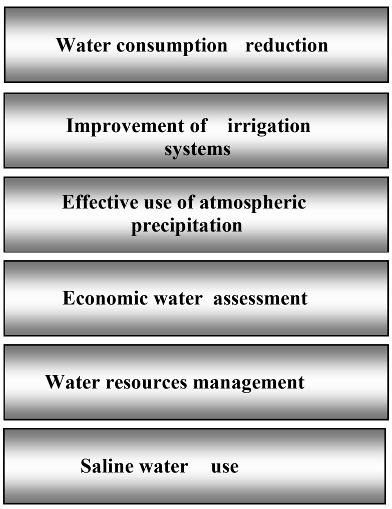


Fig. 2.9. **Main ways of raising water availability.**

The increasing deficit of water resources may again give rise to discussions on replenishing them with water from high-water rivers (rivers in Siberia and in the Caspian Sea Basin, etc.).

2.2. Agriculture: Assessing Possible Losses and Benefits

Problems of vulnerability and adaptation to uncertain future conditions do not attract due attention of public figures and the general public. Therefore a study of vulnerability and adaptation requirements is required based on the example of the existing climatic variability and observed extreme climatic situations. This will permit to assess the extent of vulnerability to climate change and adaptation possibilities, and identify specific interventions.

To accomplish this task, an analogue approach has been used in selecting scenarios. It is based on the selection of years with the instrumental monitoring data similar to conditions of the future warmer climatic conditions. This approach permits to obtain geographically targeted assessments of daily values of the required meteorological parameters for the application of crop patterns and assess the past negative impact on the country's agriculture. One of the options of the analogue approach is to use the past extreme values (for instance, values of 90-% probability empirical quantiles of average monthly temperatures) and relevant changes in agro-climatic parameters as scenarios.

2.2.1. Climate Change and Land Degradation in Uzbekistan

Climatic factors of land degradation. Land degradation in arid and semi-arid zones resulting from various factors including climate change and human activity is only a part of the general process of desertification.

Under natural conditions this process is active in the arid zone characterised by extreme climatic conditions. The most substantial climatic factors of desertification in Uzbekistan are spring and autumn drought as well as dry and strong winds, and sand storms. Prevalence of evaporation over moisture accumulation gives rise to salinity, which is especially intensive in desiccated areas of lakes. Climatic parameters (such as air temperature and humidity, atmospheric precipitation, wind, etc.) determine intensity of physical evaporation, the extent of soil moisture and therefore deflation and erosion.

Evaporation from the surface of water bodies, irrigated lands and watered pastures as well as transpiration of plants increases during drought. Regular repetition of such phenomena leads to salt concentration in soil, higher groundwater salinity and desiccation of the upper soil layer. Physiological functions of plants are upset as a result, some of their organs are damaged, and the plants may die.

Human activity intensifies natural land degradation processes, including those on improved lands. In Uzbekistan degradation of irrigated lands occurs as a result of secondary soil salinisation, irrigation and wind erosion, reduction in the content of humus and organic matter, soil pollution with pesticides, water-logging, and development of pathogenic fauna, phytofagues, farm pests, etc.

Land salinity is the main factor of desertification in Uzbekistan. Secondary salinisation of irrigated lands is caused by intensification of salt transportation in the aeration layer, especially in the event of a high saline groundwater table, as well as by arrival of salts with irrigation water and salt transport during salt and dust storms.

At present the area of saline irrigated lands in he Republic of Uzbekistan constitutes approximately 52 per cent of the total irrigated area, of this area 18 per cent are medium and strongly saline. The highest salinity is observed in Karakalpakstan (90-95 per cent), Bukhara Province (96 per cent), Khorezm oasis (95-100 per cent) as well as in Navoi (87 per cent), Jizzak (88 per cent) and Syrdarya (83 per cent) provinces. About half of irrigated lands are saline in Kashkadarya, Surkhandarya and Ferghana provinces (see Table 2.2). Soil salinity decreases crop yields. Especially unfavourable conditions as regards soil salinity exist in Karakalpakstan where most significant drops in crop yields are observed (see Fig. 2.10).

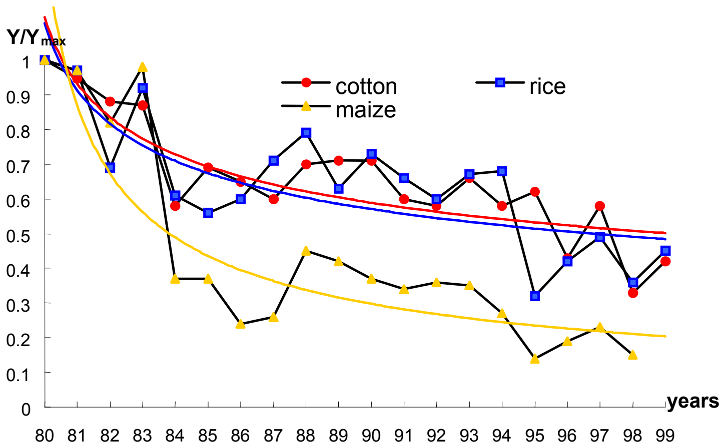


Fig.2.10. **Changes in crop yields in Karakalpakstan.**
Y/Y_{max} – ratio of yield in a certain year to maximum yield.

To reduce the extent of soil salinity operational and capital flushing is carried out. Depending on the extent of soil salinity the number of flushing sessions varies between 1 and 4, and on heavy and saline soils it increases to 5. A comparison of the frequency of flushing and crop yields shows that the former help raise the yields by 10 to 40 per cent on the average.

An increase in the area of irrigated lands is generally related to a low efficiency of irrigation systems (0.56 in Karakalpakstan, 0.58 in Bukhara Province, from 0.61 to 0.68 in the other provinces, and only in Jizzak and Syrdarya provinces it is as high as 0.75 to 0.77). Depending on the availability of drainage and natural conditions, from 15,000 to 40,000 ha (?) of salts are evacuated from irrigated lands. However, at present the efficiency of artificial drainage is falling.

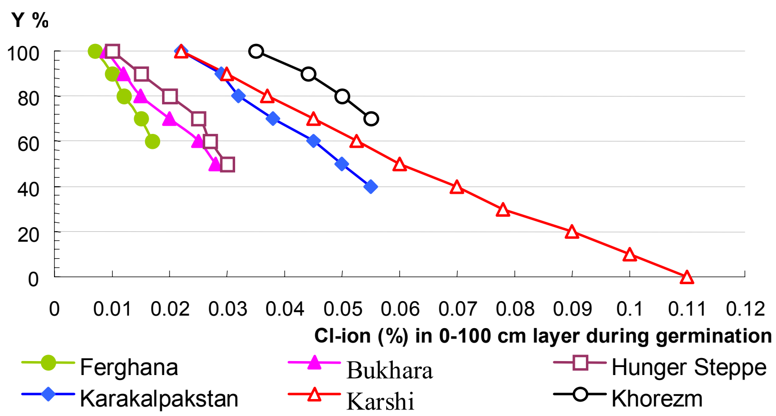


Fig. 2.11 Drop in cotton yields (%) depending on soil salinity.

Salinity increases as a result of salt migration from deep-lying water-bearing horizons (like, for instance, in the Khorezm oasis). As field observations have shown, a high extent of soil salinity before sowing leads to a considerable drop in yields (see Fig. 2.11).

At present 120,000 ha of irrigated lands in Karakalpakstan, 50,000 to 60,000 ha in Bukhara and Syrdarya provinces each, and over 30,000 ha in Karshi and Khorezm provinces are in unsatisfactory condition, while in the remaining provinces this figure varies between 5,000 and 20,000 hectares in each.

Thus, extensive development of new lands, mistakes and omissions in their design and development, low quality of land reclamation, unsatisfactory use of lands and operation of irrigation systems in general have led to progressive degradation of irrigated lands.

Soil erosion. Wind erosion has affected 56 per cent of all irrigated lands in Uzbekistan, mostly in Karakalpakstan (98 pr cent) and in Khorezm (92 per cent). To a lesser extent wind erosion is present in Andijan, Navoi, Samarkand and Tashkent provinces (see Table 2.2).

At present irrigation water erosion is present on 19 per cent of irrigated lands, and it removes from 40 to 80 tons/ha of the upper soil layer on the average during the vegetation period. The most intensive water erosion is taking place in Surkhandarya Province where it is present on 57 per cent of irrigated lands (see Table 2.2).

Table 2.2. Current condition of irrigated arable lands from the viewpoint of extent of soil erosion and salinity (in percentage of the irrigated area)

Provinces	Soil erosion (%)		Soil salinity (%)	
	Water	Wind	Total salinity	Of this area medium & strong salinity
Karakalpakstan	21.4	97.6	90.0	38.9
Andijan	7.6	27.2	9.2	4.6
Bukhara	2.2	58.5	95.7	37.6
Jizzak	17.0	73.7	97.9	39.3
Kashkadarya	14.6	74.0	47.9	13.2
Navoi	0.9	11.3	86.9	33.5
Namangan	22.1	50.7	23.6	4.1
Samarkand	28.6	18.2	3.6	1.4
Surkhandarya	57.2	52.0	42.9	16.5
Syrdarya	14.6	68.8	83.1	30.9
Tashkent	24.9	3.8	2.4	0.4
Ferghana	5.7	55.3	52.3	27.0
Khorezm	0.0	91.6	100	53.1
Uzbekistan	**18.8**	**55.7**	**52.2**	**18.4**

Soil degradation is directly related to the loss of 40 to 50 per cent of humus as a result of cotton mono-culture, low norms of application of organic fertilisers, reduction in crop rotation cycles and the area of land under alfalfa and other grasses as well as the toxic effect of residual nitrate nitrogen in the entire thickness of soil and in subsoil water (after their excessive application during intensification of agricultural production).

Thus, a high extent of land degradation and a drop in irrigated soil productivity due to the impact of climatic and reclamation conditions are currently observed in Uzbekistan, aggravating situation in the country's agrarian sector.

Climate change impact. Land degradation is bound to intensify due to climate change and increase in air temperature, especially as a result of secondary soil salinity in case of a high subsoil water table (0.5 to 1.5 m).

Estimates have shown that during winter flushing under extremely high temperature conditions (over 90 per cent of empirical quantiles) evaporation from the water surface of flushing checks will increase by 20 to 70 per cent, and the intensity of subsoil water penetration into the aeration layer and salt transportation will rise in all provinces (10 to 50 per cent), while in Khorezm and Karakalpakstan they will reach 70 per cent. In spring, depending on mechanical soil composition, the intensity of salt penetration into the aeration layer will increase by 5 to 26 per cent, while in summer and autumn is will rise by an average of 15 per cent.

Therefore, the tendency towards an increase in the saline land area and salinity level is a consequence of changing climatic conditions. Reduction in water availability to crops will affect both the reclamation condition of land and crop productivity.

As the air (and soil) temperature increases, especially in case of a high content of nitrate nitrogen and salinity, the incidence of verticillous wilt on cotton and other plantations will rise, with the exception of maize and sorgo, which are immune against the wilt carrier. In case of a 2-3º C rise in temperature above the average multi-annual one a 20 to 40 per cent higher incidence of diseases should be expected among low-immunity plants.

A more intensive salt transport from the desiccated Aral Sea bottom is expected within the next 20 to 30 years due to increasing evaporation and changes in circulation processes. This will lead to a drop in crop productivity and a rise in soil salinity in the areas affected by salt and dust transport, primarily the Aral Sea littoral area as well as Khorezm and Bukhara provinces.

2.2.2. The Impact of Climate Change on Main Farm Crops

It is common knowledge that the share of variability of farm crop yields resulting from annual vacillations in meteorological conditions during vegetation does not generally exceed 5 to 20 per cent. The highest yields correspond to a high farming culture, optimal climatic conditions and water availability.

However, yields of farm crops in consecutive years in the period of 1985 through 2000 changed by 40 to 50 per cent in Karakalpakstan and Jizzak Province, 20 to 30 per cent in the Ferghana Valley and Tashkent as well as in Syrdarya and Khorezm provinces. The most stable yields of 7 to 15 per cent variability are observed in Bukhara, Navoi, Kashkadarya, Samarkand and Surkhandarya provinces.

The impact of climate change on the productivity of the main farm crops has been assessed using a dynamic model, which includes blocs on photosynthesis, breathing and growth in the formation of crop yields. The data on maximum and average ten-day air temperatures, air humidity and duration of sunshine corresponding to analogue years have been used in computations. The influence of water deficit on crop productivity has been assessed using a water consumption model. Computations have been carried out for actually observed air temperatures (90 per cent empirical probability quantiles) and scenarios of a 1 to 3º C increase in the average temperature, with the concentration of carbon dioxide remaining at the current level.

As the temperature rises, the dates when it exceeds the biological limits and vegetation phases shift, and this requires a shift in sowing periods of crops to earlier dates, otherwise the generation phase will proceed at higher than optimal air temperature. A shift in sowing dates by 5 to 10 days will cause a 10-20 per cent drop in crop yields (see Fig. 2.12).

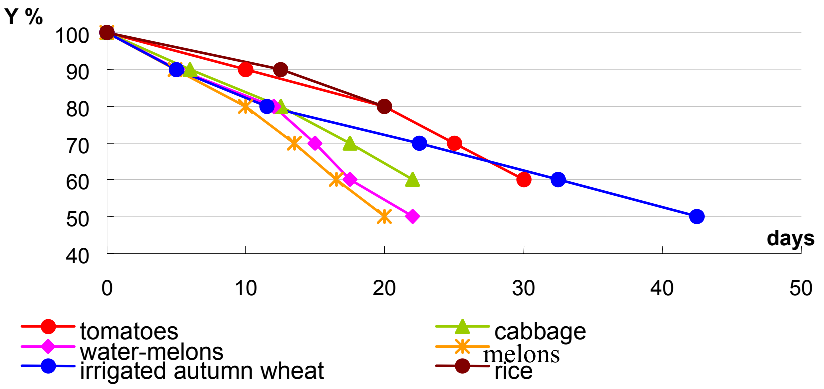


Fig. 2.12. Changes in crop yields (Y%)depending on the shift in sowing dates.

In the event of a 2-3º C increase in temperature rice yields of average-ripening and average-late varieties in all crop-farming areas will drop to 80-95 per cent of the current ones, and the yields of late varieties will either drop to 80 per cent or remain the same. In the event of subsequent temperature increase rice yields will be down to 55-80 per cent.

Maize yields will drop by 20 to 30 per cent in extremely warm years, while under the other scenarios they will decrease by 10 to 15 per cent.

As for cotton, given optimal water availability and the existing condition of lands, yields may increase by 3 to 12 per cent in case of a 1-2º C rise in air temperature and optimal sowing dates. In case of a further 2-3º C increase its yields will be down by 2 to 4 per cent.

As regards the Ferghana Valley and Samarkand Province, temperature rise will generally have a favourable effect under the accepted scenarios and lead to a 2 to 10 per cent increase in yields.

In Surkhandarya Province temperature exceeding the normal one by 2-3º C will decrease crop productivity by 4 per cent, and in Karakalpakstan by 2-3 per cent.

However, according to estimates, an increase in the number of days with an air temperature higher than 39º C may lead to an additional drop in cotton yields by 5 to 20 per cent (see Fig. 2.13).

In conditions of low efficiency of irrigation systems and limited water resources, water availability to irrigation remains low. Only 40 per cent of water arriving at the province boundary reach the crops (losses in irrigation networks constitute 40 per cent and losses during watering amount to 20 per cent).

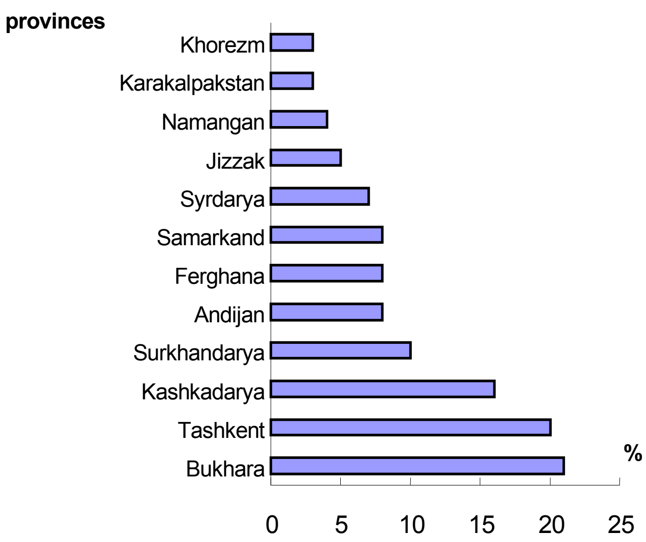


Fig. 2.13. Possible drop in yield (percentage of cotton) in case of an increase in the number of high temperature days under a scenario of 2-3º C average temperature increase.

A decrease in water availability to 80 per cent of the required amount leads to a 15 to 18 per cent reduction in the yields of farm crops. And in the event of a 50 per cent water availability losses in yields may amount to 35-49 per cent (see Fig. 2.14).

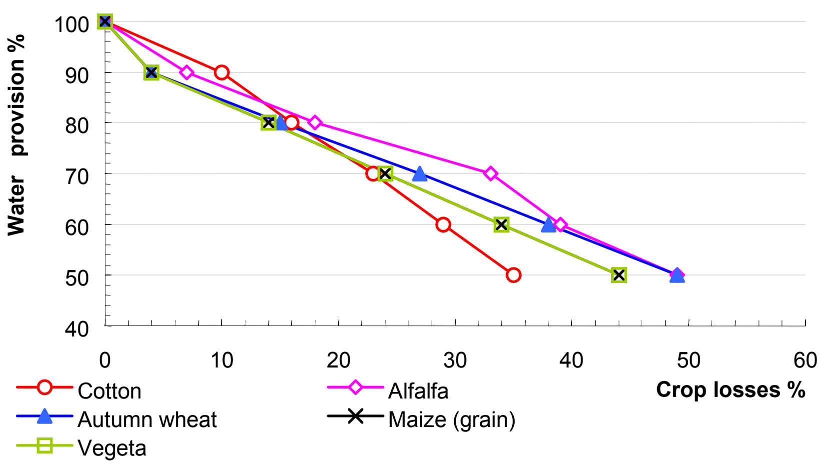


Fig.2.14. **Loss of farm crop yields depending on water availability during vegetation.**

In condition of low water availability the stress increases with the increasing number of days with high air temperature. During vegetation periods crop losses constitute 20 to 25 per cent (Fig. 2.15).

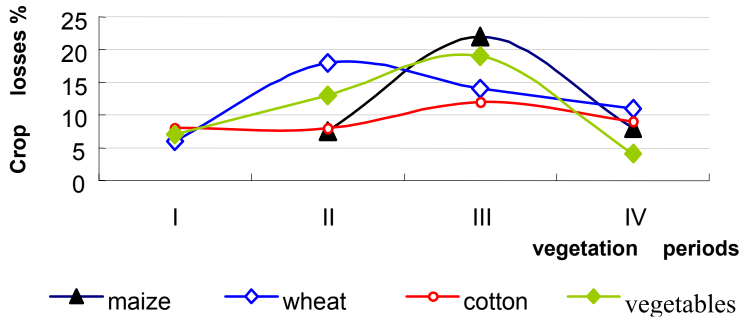


Fig. 2.15. Crop losses in case of 50% deficit of water availability in vegetation periods.

Given the current agricultural practices in autumn wheat cultivation (both on rain-fed and irrigated lands), an increase in the number of days with a temperature exceeding the normal one by 5º C in March and April will result in a 50 to 80 per cent loss of yield in conditions of low water availability.

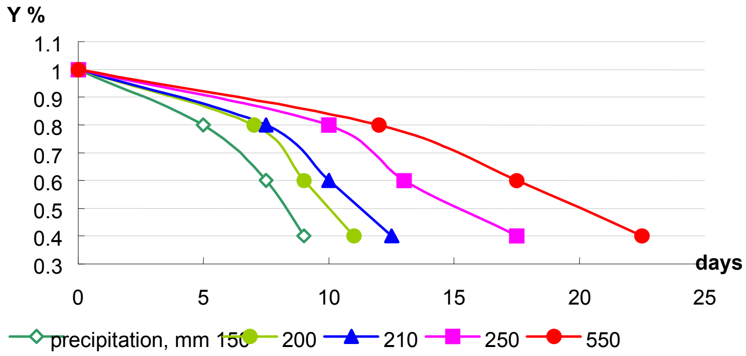


Fig. 2.16. Changes in autumn wheat yields in case of an increase in the number of days with the temperature exceeding the normal one by 5º C (March-April) depending on the sum total of precipitation during vegetation period.

Under the same conditions of water availability, but using advanced agricultural practices and securing an optimal application of mineral fertilisers yield losses will be considerably lower. For instance, in case of a 500 mm irrigation norm (or sum total of precipitation), an increase in the number of days in March and April with a high temperature exceeding the normal one by 5º C will lead to a 50 to 60 per cent drop in yields, while advanced farming practices and a good choice of drought-resistant crops could result in only 10 to 15 per cent decrease in yields (see Fig. 2.16).

2.2.3. Possible Losses and Benefits, Adaptation Interventions in Crop Farming

In the event of concentration of carbon dioxide in the atmosphere, the impact of climate change will be less destructive for agricultural production. The intensity of photosynthesis will increase as well as crops productive ability. In case of a 1-2º C temperature rise yields of the main farm crops may rise (cotton by 7 to 12 per cent and cereals by 7 to 15 per cent) given optimal sowing dates, normal water availabilitys and flushing of saline lands. Increasing rates of plant development and vegetation phases will require adaptation of quick-ripening crops or introduction of later-ripening ones.

Possible benefits to crop farming resulting from climate change:

- shorter period of ripening and a rise in early crops production;

- longer vegetation periods of industrial crops (especially cotton), which will result in the opening of a greater number of ripe balls;
- lower grain losses during the harvesting of cereals;
- expansion of growing areas of medium- and late-ripening crops towards the North.

Possible losses. A possible increase in yields due to higher concentration of carbon dioxide will not be achieved in case of application of outdated farming practices, water shortage, soil salinity and lack of organic and mineral fertilisers.

A 2-3º C or more rise in temperature under the current water availability conditions (or, possibly, even lower in future) will lead to a considerable reduction in farm crops productivity, especially if the optimal sowing dates and irrigation regime are not observed.

Productive water consumption of irrigated crops during vegetation will increase by 10 per cent on the average, which will require an increase in net irrigation norms and water withdrawal from irrigation sources accordingly. It is necessary to provide for 5 to 10 per cent higher flushing and moisturising norms due to an increase in evaporation in autumn and winter.

The intensity of salt and dust transport will grow, especially in condition of a high groundwater table, which will result in intensification of salt accumulation.

After a large-scale cutting of public and on-farm protective belts, that had existed before the 1980s the impact of dry winds and wind erosion on the crops has increased, and higher temperature will intensify this negative tendency.

Thus, under the existing conditions in irrigated farming a rise in air temperature will intensify the process of soil salinisation and reduce the yields of currently cultivated farm crops.

Adaptation to climate change. A 1-2º C rise in air temperature will not necessitate any radical reorganisation in crop patterns, while a 2-3º C rise will necessitate the introduction of drought- and salt-resistant crops.

The main interventions should include prevention of secondary land salinisation, introduction of water conservation techniques as well as new methods of irrigation and farm crop cultivation. Reduction of specific water consumption on flushing and vegetation watering may be achieved by the following interventions

- Reconstruction of irrigation and drainage networks as well as their timely clearance;
- Improvement of existing irrigation techniques (application of surface watering along shorter furrows, watering at night, etc.);
- Introduction of the latest watering techniques (impulse, discrete, subsoil and drop irrigation and sprinkling, etc.);
- Reduction in the area of on-farm fallow lands and the length of transit canals;
- Introduction of new crop cultivation technologies (sub-film watering, use of seedlings, etc.).

To mitigate the impact of climate change on agricultural production it will be necessary to:

- Observe a set of agricultural practices (crop rotation, dates and norms of application of mineral and organic fertilisers, introduction of biological methods of plant protection, etc.);
- Maintain the optimal condition of irrigated lands and take erosion control interventions;
- Select and introduce drought-resistant quick-ripening varieties and hybrids with low water consumption per unit of produce;
- Change sowing dates depending on the prevailing hydro-meteorological conditions;
- Optimise crop patterns and varieties, especially of irrigated autumn crops with due regard for changes in the river run-off in the event of operation of water reservoirs in the power-engineering mode;

- Take protective interventions in the desiccated part of the Aral Sea in order to reduce salt transport into irrigated territories and pastures;
- Increase atmospheric precipitation by an active impact on clouds;
- Restore protective belts and create new ones around irrigated lands.

Protective forest belts improve air quality, regulate air temperature and humidity over irrigated fields, act as biological drains, and reduce the intensity of groundwater rise as well as soil salinisation and water-logging, which generally increases crop yields and improves the environment. Experiments have shown that protective forest belts decrease wind velocity over irrigated fields by 20 to 70 per cent and evaporation of moisture from fields by 10 to 30 per cent, and raise the yields of various crops by 10 to 15 per cent.

It is necessary to improve the system of monitoring the state of farm crops, reclaimed lands and methods of forecasting dangerous weather phenomena such as frosts, intensive rainfall, air drought, etc., and inform consumers to the effect so they could take measures to reduce possible damage from the expected unfavourable phenomena.

2.2.4. Assessing the Impact of Climate Change on Natural Pasture Degradation

Human-induced factors of pasture degradation. Increasing pressure on pastures, geological exploration, development of mineral deposits, construction of gas and water pipelines, populated areas and irrigation facilities, the cutting of arboreal and shrub vegetation for firewood and land salinisation upset the balance in the ecosystems and give rise to or intensify pasture degradation.

Overgrazing leads to a reduction in pasture productivity, and sometimes to a complete destruction of fodder vegetation. The area of low-productivity territories around settlements increases, and vegetation around wells is totally destroyed.

Various indicators are used to monitor the process of pasture degradation including such most important one as vegetation cover. Agro-meteorological data obtained on the ground as well as aerial photography and satellite imagery permit to trace multi-annual changes in yields and study them, and to identify territories susceptible to degradation.

The impact of climatic factors on the yields of pasture vegetation. The main factors of growth, development and formation of the yields of pasture vegetation are the temperature regime and the moisture regime. For this reason climate change will have a great impact on pastures.

Considerable deviations from the norms of seasonal warmth and moisture availability determine the varying intensity of pasture vegetation growth, the extent of pasture overgrazing and, therefore, the general condition of pastures and provision of cattle with fodder.

A 1-3º C rise in temperature will lead to a 5-14 day shift in vegetation resumption to earlier dates, as a result of which in the central part of the Kyzylkum desert it may begin as early as the last ten-day period of February. Vegetation of ephemers will shift to a period of more intensive rainfall (March-April), which will create more favourable conditions for them. Yields computed on the basis of climatic data may rise by 0.1-0.2 c/ha. Water availability of that year will play a crucial role.

For instance, in years of high water availability a deviation of ten-day temperature by 2 to 6º C above the norm lead to an 8-cm increase in the growth rate of sedge (Corex) and an up to 6-cm increase in the growth rate of wormwood (Artemisia). In years of medium water availability the same temperature deviations lead to a smaller increase in their growth rate (2-4 cm for sedge and 0-2 cm in wormwood). In dry years a rise in air temperature has a negative impact on vegetation, especially on sedge, which grows 2-4 cm slower.

Therefore, an increase in air temperature will only lead to an increase in the growth of pasture vegetation in water-abundant years, and will have a negative impact in dry ones, which will bear a harder pressure on pastures.

Pressure on pastures. Both excessive and insufficient pressure is harmful for pastures. In case of correct use of pastures the grazing of cattle raises their productivity and improves the composition of fodder crops. Therefore the number of heads of cattle to graze should be set according to the feeding capacity of pastures.

The percentage of the actually grazing cattle to the number of heads a pasture can feed without any detriment to itself characterises the pressure on this pasture. The following schematic map shows that the pressure on southern and eastern regions of pastures is already too high (see Fig. 2.17).

In years of minimal yields when the annual fodder reserve constitutes 50 to 70 per cent of the norm the grazing cattle eats up practically the entire reserve. In such years the pressure on pastures increases. In northern areas it moves close to the norm (80 to 100 per cent), in the western and central parts of the Kyzylkum desert it rises to 170-190 per cent, in the areas close to Bukantau and Jamytau mountains as well as in the eastern part of the Kyzylkum it increases to 230-260 per cent, and in southern areas it reaches as much as 300 per cent.

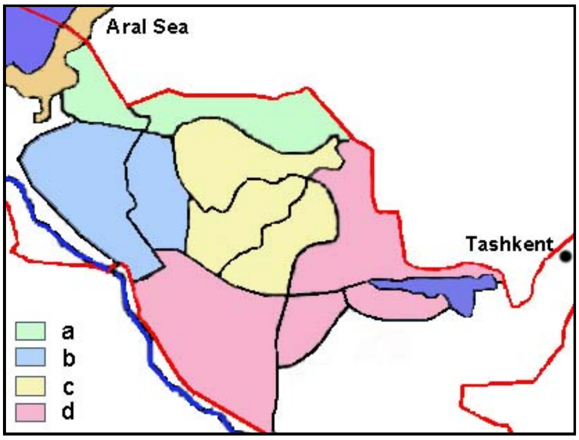


Fig. 2.17. Distribution of the pressure on agro-climatic zones of karakul-sheep breeding pastures of Uzbekistan.
Conventional symbols:
a – weak pressure, less than 80 %;
b – normal pressure, 80 to 120 %;
c – overpressure, 120 to 160 %;
d – strong overpressure, more than 160 %.

In the past two decades there were four low-yield years in the eastern part of the pasture territory, 3 low-yield years in the north-western part, two such years in the north and near Tamdytau and Kuljuktau, and one in the remaining areas. Thus the eastern area is the worst one as regards the pressure on pastures and their condition.

Tendencies of growth and yields of pasture vegetation. An analysis of tendencies in the development of pasture vegetation in the past 30 years has shown a decrease in the maximum height of sedge, one of the main fodder crops, in western and northern parts of the Kyzylkums (see Fig. 2.18).

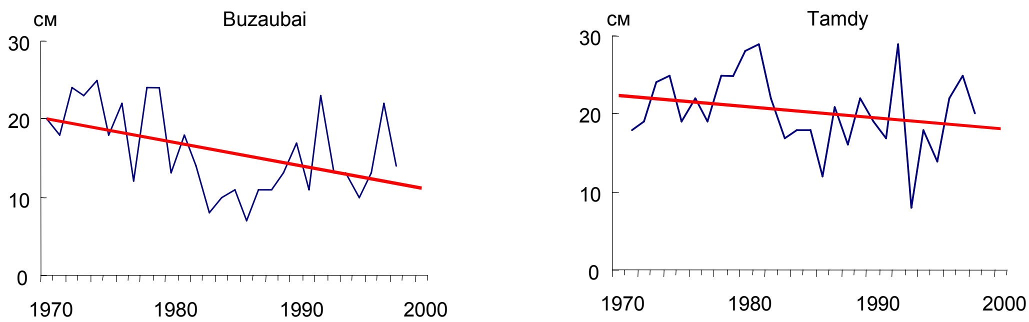


Fig.2.18. Changes in the height of sedge plants in the western (Buzaubai) and central (Tamdy) parts of the Kyzylkum desert.

A negative tendency in yields is observed in the northern areas of Karakalpakstan and in some areas in Navoi Province. In the other areas, changes in the vegetation mass correspond to changes in agro-meteorological conditions. Areas with negative yield tendencies are characteristic of the territories with intensive salinity spots (see Fig. 2.19).

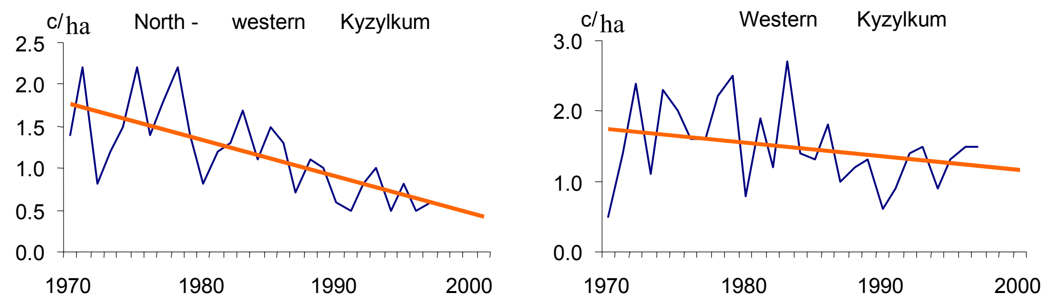


Fig.2.19. Multi-annual course of yields of pasture vegetation computed on the basis of satellite data in some parts of the Kyzylkum desert.

An indicator of pasture degradation is also the area with spring yields of pasture vegetation of 0.5 c/ha and less. The past decade has witnessed a considerable increase in such areas in Karakalpakstan (Fig. 2.20). Areas with spring yields of 0.5 c/ha and less in some years constituted 65 per cent in the central districts of Navoi Province and 50 per cent in the eastern part of Bukhara Province.

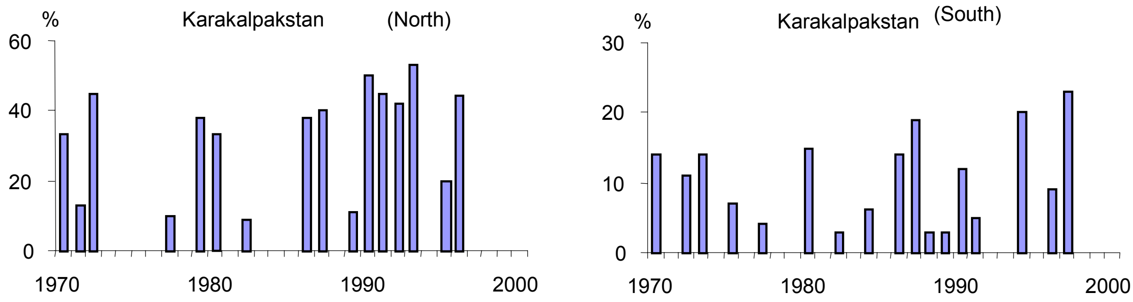


Fig.2.20. Percentage of areas with yields of pasture vegetation of less than 0.5 c/ha.

An increase in the areas with low yields is connected with the deteriorating condition of soil manifested in its salinity. The actual cause of a drop in pasture yields in the western and north-western parts of the Kyzylkums is their proximity to the Aral Sea disaster area.

The impact of increasing salt-and-dust transport on pasture degradation. Pasture salinity leads to a reduction in their biological productivity and general condition. A major role in it is played by the salt-and-dust transport largely connected with an intensive desiccation of the surface soil layer, which intensifies wind erosion and transportation of large amounts of salt and dust.

A major source of salt-and-dust transport is the desiccated part of the Aral Sea bottom, the surface of saline discharge accumulation lakes and solonchaks. In Bukhara Province alone there are about 120 km^2 of such sources of salt. The total mass of salts subject to aeolian transport in Bukhara Province constitutes 167,136,000 tons annually, and approximately 13,800 tons of this amount come from the solonchaks.

In the Aral Sea littoral area the surface of solonchaks exceeds 4,000 km^2. In some years the total amount of salt transport in that area comes to 7,685 tons/km^2. This necessitates a reduction in the amount of transported salt and dust components. One of the ways to do so is to anchor the surface layer with the help of polymer covers acting as chemical ameliorators.

2.2.5. Adaptation and Pasture Degradation Prevention Interventions

Phyto-reclamation interventions play an important role in preventing pasture degradation. Their aim is to create artificial ecosystems with a higher productivity than the productivity of natural phytocenoses on various types of pastures.

The main phyto-ameliorators in Uzbekistan are Haloxylon aphyllum, Aellenia subaphylla, Kochia prostrata, Salsola orientalis and Salsola Arbuscula.

Considering the extent of pressure on pastures farms should take interventions promoting a more sustainable use of pasture territories. For instance, in the north-western part of the Kyzylkum desert where conditions for pasture vegetation are deteriorating despite a small pressure on pastures, it cannot be increased. The pressure cannot be increased either in the western part of the pasture territory where the pressure is close to the norm but conditions of vegetation growth are also worsening. In the areas where pastures are overloaded the pressure should be decreased (see Fig. 2.17).

In order to reduce the negative impact of salt-and-dust transport on pasture productivity chemical reclamation should be used for anchoring soils, sand and salts with the help of polymer compounds and other means.

2.2.6. Study of the Impact of Climate Change on the Condition and Grazing of Livestock Such as Karakul Sheep

Normal vital activity of the organism of livestock can only proceed under optimal conditions, of which meteorological factors are very important. These factors influence the extent of tension in the thermo-regulatory systems of the organism, resistance to diseases, growth and development, and determine the productivity of animal husbandry in general.

Intensive solar radiation and high air temperature have a depressing effect on sheep. High thermal pressures lead to higher tension in the functions of the organism (thermal stress), which entails ineffective consumption of nutrients, when 30 to 40 per cent of their energy is spent on thermal regulation. This decreases the nourishment of livestock and causes higher disease incidence among Karakul sheep.

Thermal pressures depending on a number of meteorological factors (such as solar radiation, air temperature and humidity, soil temperature, wind velocity, condition of the woollen hides of animals, their physiological state, etc.) are computed on the basis of a thermal balance method.

Fig. 2.21 presents a multi-annual course of maximum thermal pressures (Pr) in the month of July over the past 40 years in western areas of the Kyzylkum desert (Buzaubai). Along with inter-annual variations there is an obvious tendency towards an increase in the thermal pressure resulting from climate change. Thermal pressure is sufficiently closely connected with the air temperature (see Fig. 2.22). For instance, at Buzaubai station the thermal pressure increase by more than 4 W per each degree of maximum air temperature.

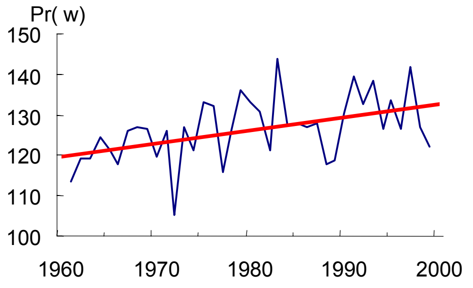


Fig. 2.21. Multi-annual course of maximum thermal pressure (Buzaubai, July).

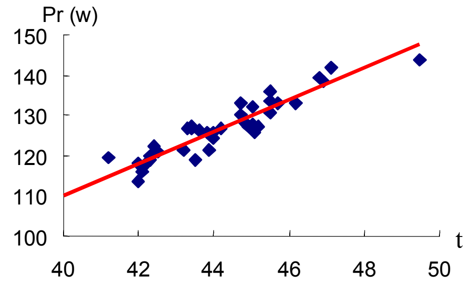


Fig. 2. 22. Dependence of the values of maximum thermal pressure on air temperature (Buzaubai, July).

Karakul sheep are staying on pastures all year round, therefore of great importance is identification of meteorological factors making it impossible for the sheep to graze.

Winter period. Karakul sheep breeding experiences the most difficult conditions in winter, when the impact of low air temperature and the wind in combination with snow cover, ice and other unfavourable phenomena leads to termination of sheep grazing, causes respiratory diseases, and in most severe cases results in the death of animals.

The main indicator of availability of favourable climatic conditions for the wintering of Karakul sheep is the average number of non-grazing days (NNGD), when the sheep cannot graze. During the non-grazing period they require feeding, therefore farms create fodder reserves. Their amount depends on the average NNGD and varies from 8 kg pr one head of female sheep in the South of the Kyzylkums to 46 kg in the North; and from 7 to 51 kg per one head of young animals respectively.

The number of non-grazing days depends on a number of factors including air temperature. A rise in temperature will decrease the NNGD and the amount of fodder reserve (see Table 2.3).

Table 2.3. Reduction in the average NNGD and the amount of fodder reserve (dry-air mass, kg per head) in case of a 1-3° C rise in air temperature

Area	Reduction in average NNGD		Reduction in fodder reserve, kg per head	
	Female sheep	Young sheep	Female sheep	Young sheep
Northern	5-9	6-12	16-28	15-29
Central	1-2	1-3	3-9	2-7
Southern	0-5	1-2	2-5	1-5

The spring period is the most important one in karakul sheep breeding in Uzbekistan. It is the time of having lambs and shearing sheep.

In the first weeks of their life lambs are very susceptible to such unfavourable weather conditions as low air temperature, precipitation, snow cover, etc., which may cause respiratory diseases and even their death. A 1-3° C rise in temperature will have a favourable impact on the time of having lambs because the number of cold days in March will decrease by 1 or 2 days per each ten-day period.

During the shearing a rise in air temperature will add one hot day per each ten-day period. This will have an extremely negative impact on the condition of Karakul sheep during shearing if carried out at the same time as it is done now, because animals will fall under the effect of increased thermal pressures.

In case of a 1° C increase in air temperature the beginning of shearing may shift by 3 to 5 days. A more substantial rise in air temperature, by 2-3° C, will cause a shift to earlier dates by 10 to 15 days. In conditions of unstable spring weather special attention should be paid to weather forecasts, since cold may have a harmful effect on the sheared sheep.

Summer period. Conditions in hot summer months are most hard for the sheep, on some days the period of thermal stress may continue for as long as 9 hours and more.

Thermal stress of long duration may upset thermal exchange processes, affect cardiac activity and digestion, decrease daily increase in weight, and even cause a loss in the live weight starting from a certain heat level.

Studies have shown that a rise in air temperature will lead to a considerable increase in the number of unfavourable hot days (NUHD) in summer (see Table 2.4).

Table 2.4. Increase in the average monthly number of unfavourable hot days in summer

Rise in temperature, °C	Increase in the number of days with a duration of thermal stress of	
	Over 3 hours	Over 6 hours
1	2.6	2.0
2	5.2	4.0
3	7.8	6.0

The available data point to the need for shading in the period of maximum insolation. Under the sun the frequency of respiration in sheep increase by 258 per cent, oxygen consumption increases by 232 per cent, and metabolism accelerates by 66 per cent as compared to the shade.

Computations have shown that shading may reduce the thermal pressure on the sheep organism by 50 to 80 W. The use of shades will raise animal productivity and their live weight, and reduce morbidity and mortality.

Autumn period. After the summer heat there comes a more favourable period for the sheep. However, even then thermal stresses may occur due to a high temperature in daytime. The expected rise in temperature may increase the number of NUHD by 0.5-1.7 days per each ten-day period. An increase in the number of hot days will necessitate a shift in shearing time to a later dates because both the amount of the wool sheared and the health of sheep depend on its timeliness. However, it is mandatory that the shearing be completed a month before cold weather sets in.

In case of a rise in temperature the unfavourable cold period will shift to later dates by 10 to 15 days throughout the entire territory of desert pastures.

Therefore a rise in air temperature may shift the Karakul sheep shearing period by approximately ten days.

2.3. Climatic Observation, Monitoring and Assessment of Current Climate Changes; Methods of Generating Regional Climatic Scenarios

2.3.1. Systematic Climate Monitoring

Systematic and all-round climate monitoring aims to improve our understanding of the global climatic system as well as mechanisms leading to climate variability and change. However, the existing global networks of climate monitoring require improvement and development. Preparation of National Communications on systematic monitoring systems will permit to co-ordinate efforts and support national and international agencies in developing and strengthening the Global Climate Observing System (GCOS).

National conditions of networking. The most developed monitoring network existed in Uzbekistan prior to 1986, the further period witnessing a steady reduction in both the number of stations and posts and the scale of observations conducted at them. By now the situation with hydro-meteorological monitoring has stabilised in Uzbekistan but remains complicated (see Table 2.5).

Table 2.5. Changes in the number of monitoring posts

Type of monitoring	Number of monitoring posts by years			% of 1986	
	1986	1998	2001	1998	2001
Meteorological	95	76	**77**	80.0	81.1
Hydrological	197	1379	**147**	69.5	74.6

The ground hydro-meteorological monitoring network of Uzbekistan is comprised of 77 stations conducting meteorological monitoring; 147 posts conducting hydrological monitoring and 89 posts conducting agro-meteorological monitoring (two of them are agro-meteorological stations).

Economic reasons, which caused a reduction in the monitoring network, have also had a diverse impact on the provision of hydro-meteorological network with instrumentation, equipment, spare parts and consumables. The existing instruments are on the verge of collapse. The number of probing stations has reduced catastrophically, only one aerological station has remained, and two stations have been laid-up. The national hydro-meteorological service (NHMS) of Uzbekistan does not have sufficient funds for network reorganisation and development as well as construction and maintenance of the network in operating conditions. For this reason a number of stations and posts, although they continue to operate, have either reduced the scale of monitoring or stopped it completely.

Such a state of affairs may have a negative impact on the quality of climate data as well as weather and river regime forecasts. Studies in the areas of hydro-meteorology and climatology including such important issues as climate change and assessment of its impact cannot develop without reliable and representative data. Urgent interventions should be taken to remedy the current situation, but not a single Central Asian state can afford them alone. They need to join their efforts and enlist support from the international community.

A special programme of optimising the monitoring network is required with the aim of retaining the most important monitoring posts, minimising their maintenance costs and bringing it into conformity with modern requirements as regards both management, technical equipment and forms of hydro-meteorological support to consumers. The main reasons necessitating the formulation of a special programme to strengthen the climate monitoring system in Uzbekistan are these:

- new economic conditions in the country;

- reduction in the number of monitoring posts due to insufficient budget funding;
- insufficient co-ordination of concepts of establishing various monitoring networks;
- the need to bring the functions of network monitoring agencies in conformity with the requirements of the WMO and the GCOS.

Meteorological observations conducted by Glavhydromet of Uzbekistan at present are based on the best practice and climatic monitoring principles. However, for a number of reasons (such as urbanisation, increase in the area of irrigated lands, construction of water reservoirs and irrigation drainage lakes and desiccation of the Aral Sea) the uniformity of climate monitoring series is disrupted at some stations. The difficulties in replacing old instruments with new ones and securing the required engineering level may upset the best practice principles at many stations in the nearest future.

Level of automation of monitoring. The level of automation of monitoring is rather low in Uzbekistan. Most parameters (both hydrological and meteorological) are metered by observers, who subsequently enter these data into special books. Then these data are encoded and transmitted to the data processing centre via communications.

Participation of Uzbekistan in international climatic data exchange. Uzbekistan belongs to Region II – Asia. He monitoring network of the Global Weather Service includes 62 stations, and 18 stations of this number are international exchange stations via the WMO.

The global ground climatic monitoring network includes 3 stations situated in Uzbekistan (see Table 2.6).

Table 2.6. The network of stations of the global climate monitoring system (GCMS)

Station index	Name	Latitude (º,´)	Longitude (º,´)
38262	Chimbai	42 57	59 49
38413	Tamdy	41 44	64 37
38457	Tashkent	41 16	69 16

Climatic data are transmitted on a monthly basis in the format of CLIMAT telegrams into the Global Telecommunications System (GTS). Starting with January 1, 2001 Uzbekistan transmits into the GTS channels the data of 12 stations including the 3 GCOS stations, which are accessible to the WMO and world information centres.

Maintenance and development of the regional monitoring network as the basis of GCOS improvement. The national monitoring network should be strengthened, and data collection and processing as well as the engineering base should be improved so as Uzbekistan could participate in the GCOS more effectively, like other countries.

Due to use of different types of instruments their data are incompatible, and therefore re-equipment of monitoring stations with unified instruments is possible only if their domestic manufacture is arranged. In Uzbekistan there is the 'Hydrometpribor' Research and Production Enterprises, which manufactures, services and repairs instruments. The enterprise has a certain base for the manufacture of hydro-meteorological instruments but it requires support.

A network of automated meteorological stations and remote metering methods needs to be developed. Remote sensing methods for determining snow reserve in the mountains as well as the condition and yields of pasture vegetation and farm crops designed by the Central Asian Research Hydro-meteorological Institute functioning under the Glavhydromet of Uzbekistan provide a good basis for automated environmental monitoring in the region.

A component of the World Hydrological Cycle Observing System (WHCOS) is to be established in the Aral Sea Basin. The objective of the Project 'Aral Sea – WHCOS' will be to establish an engineering and research structure for the future database of regional water resources. Implementation of the project will promote integration of Uzbekistan into the Global Land Monitoring System. This approach is necessary for developing and retaining a meteorological and aerological monitoring network in Uzbekistan. Table 2.7 lists capacity building requirements to developing the climate monitoring system in Uzbekistan.

Table 2.7. Capacity building requirements to systematic climate monitoring in the Republic of Uzbekistan

Sector	**Requirements (engineering, technological & capacity building)**
Meteorological monitoring, Climatic monitoring	Better provision of equipment to selected stations. Technical modernisation of monitoring as well as primary data processing and transmission. Establishment of meteorological stations in the mountains. Restoration of monitoring at laid-up stations (Aral Sea littoral area). Automatic stations. Modernisation of data processing and storing centre. Improvement of available databases and creation of new ones with an open access to users. Provision of appropriate PC and networks, application of GIS. Staff training.
Aerological monitoring & use of its data	Provision of stations with equipment and consumables. Technical modernisation and provision of long-term operation of automatic stations. Introduction of modern data reception and transmission system from and to AS. Improvement of data control and storage. Calibration of monitoring data in order to use remote probing data (in future). Staff training.

2.3.2. Methodological Basis for Preparing a Climate Monitoring Newsletter

Apart from strengthening and developing the monitoring system, a priority task for Uzbekistan is to arrange a regular publication of a climate-monitoring newsletter. To this end it is required to:

- establish a climatic database;
- select, adapt and apply appropriate methodologies (for the analysis of data quality and their restoration, computation of statistical indicators and mapping);
- formulate principles of creation and structure of the monitoring newsletter;
- publish a pilot issue of the climate monitoring newsletter of Uzbekistan.

Table 2.8 lists climatic parameters acting as indicators of climate change in Uzbekistan that are to be published in the monitoring newsletter.

Database preparation. The database should include a maximum possible number of stations located in different conditions as regards human-induced impact on the climate (Aral Sea area, irrigated area or urban area) and in different physical and geographic conditions. Considering the length, continuity and uniformity of monitoring series, 50 climatic stations have been selected, necessary for an objective assessment of climate change in Uzbekistan. This approach to selecting climatic stations has permitted to mitigate the input of local human-induced impacts on the climate when averaging the area of different parameters.

Table 2.8. Climate change indicators

Temperature
Annual and average monthly air temperature
Minimum air temperature
Maximum air temperature
Precipitation
Annual and monthly precipitation amounts
Maximum daily precipitation
Water resources
Run-off from the upper watersheds
Run-off in the dispersion area

Levels in internal water bodies
Mountain ice cover
Snow cover

One of the requirements of the timely publication of climatic information is automated collection, control, storage and analysis of the incoming climatic data. Therefore, in future it will be necessary to establish a climatic database, which will be replenished in time and contain verified information

The zoning and selection of reference stations. The existing meteorological stations are situated irregularly across the territory of Uzbekistan, monitoring periods at them are different, and in some parts of the country there occurs local human-induced influence on the climate, therefore a selection of reference stations is required. For monitoring purposes Uzbekistan has been divided into 14 climatic zones (see Fig. 2.23). A study of variations of average monthly temperature anomalies and averaged anomalies of monthly precipitation amounts has shown their uniformity throughout the territory of climatic zones.

Methodologies of restoration of lacking data and input data control. In creating a climate monitoring newsletter of Uzbekistan, a method of restoration of lacking data has been created based on the fields of climatic parameters (average monthly air temperature and monthly precipitation amounts) with the application of a stepped multiple linear regression.

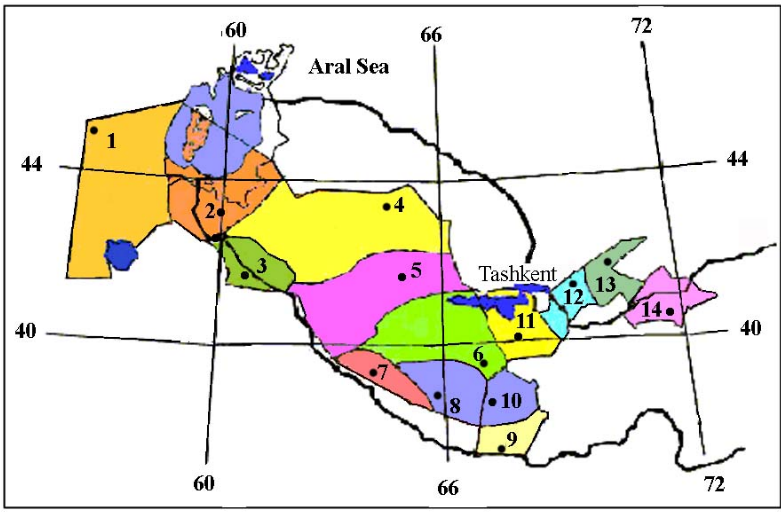


Fig. 2.23. Location of climatic zones and list of reference stations

1. Karakalpakstan
2. Chimbai
3. Urgench
4. Akbaital
5. Tamdy
6. Samarkand
7. Karakul
8. Karshi
9. Termez
10. Minchukur
11. Jizzak
12. Tashkent
13. Pskem
14. Ferghana

Air temperature data were verified by comparing each anomaly with the average deviation in a uniform climatic area. In the verification of monthly precipitation amounts anomalies expressed as percentage of the average were compared.

Climate monitoring newsletter. The climate-monitoring newsletter is based on the monthly resolution data and contains maps of monthly air temperature anomalies and monthly precipitation amounts of the past year as well as the data on the observed extreme values with an assessment of their probability. The newsletter also presents temporal trends of the main climatic parameters and brief descriptions of tendencies in the global and regional climate change. It presents an analysis of changes in water resources components such as the run-off in the upper watersheds and in the dispersion area, snow cover in the mountains, and the levels in internal water bodies including the Aral Sea. An pilot 2000 newsletter designed within the framework of the present project has already been presented to the interested agencies.

2.3.3. Assessing Changes in the Main Climatic Parameters throughout the Territory of Uzbekistan

Characteristic peculiarities of climate in Uzbekistan are that it is arid and sharply continental. The country's territory is open to the intrusion of various air currents causing sudden weather changes. Peculiarities of atmospheric circulation are the main causes of a high natural climatic variability.

Natural climatic variability is intensified by the human-induced impact, both global (such as a higher GHG concentration in the atmosphere) and local (such as large irrigated tracts of land and the continuing desiccation of the Aral Sea) assuming a mesonic scale, which makes identification of climate changes related to the global warming more difficult.

Assessment methodology. To assess changes in temperature and precipitation in the territory of Uzbekistan the data of the stations were used that have monitoring series starting with 1931. This means that there was an opportunity to check the significance of changes in average values and dispersions in the two basic climatic periods (1931 – 1969 and 1961 – 1990). Significance of values was assessed by the application of statistical criteria. The level of significance of 0.5 has been selected as the critical one. Monthly resolution data have been used as input information.

Table 2.9. Percentage of stations in Uzbekistan that have registered changes in the statistic parameters of average monthly air temperature
(1 – observed change, 2 – observed significant change)

Month	Dispersions				Average values			
	Increase		Decrease		Increase		Decrease	
	1	2	1	2	1	2	1	2
January	15.4	-	-	-	3.8	-	-	-
February	65.4	**7.7**	7.7	-	-	-	-	-
March	-	-	73.1	**7.7**	30.8	**7.7**	-	-
April	3.8	-	34.6	**3.9**	61.5	**50.2**	-	-
May	-	-	65.4	**7.7**	26.9	**19.2**	-	-
June	3.8	**3.8**	53.8	**23.1**	80.8	**69.2**	-	-
July	3.8	-	38.5	**7.7**	38.5	**23.1**	15.4	**15.4**
August	34.6	**11.5**	-	-	15.4	**11.5**	30.8	**19.8**
September	-	-	53.8	**34.6**	19.2	**7.7**	19.2	**14.4**
October	3.8	-	19.2	-	7.7	**7.7**	15.4	**7.7**
November	15.4	-	7.7	-	92.3	**92.3**	-	-
December	3.8	-	7.7	-	73.1	**50.2**	-	-

Air temperature. The assessment outputs have permitted the following conclusions. There is a slight tendency towards a dispersion decrease and a substantial tendency towards a rise in the average monthly air temperature throughout the territory of Uzbekistan. The largest increase has been observed in April, June, November and December. In those months most stations (from 50 to 92 per cent) noted a considerable rise in climatic norms of the average monthly air temperature (see Table 2.9). Thus, it can be concluded even on the basis of analysis of the average monthly temperature series that a significant increase is being observed in the territory of Uzbekistan.

The minimal temperature monitoring data have also manifested a considerable rise. For instance, in April, June and November a significant increase in the minimal temperature was registered at 78, 73 and 91 per cent of stations respectively. The distribution of temperature increase in various months throughout the territory is presented in Fig. 2.24. Changes in the November minimal temperatures bear a trace of the climatic contribution of the Aral Sea desiccation, which is expressed in less pronounced tendencies towards an increase in minimal temperatures in the Aral Sea littoral area.

It is noteworthy that in summer and autumn a tendency towards a rise in minimum rather than maximum temperatures is considerably more pronounced, and in summer a large number of stations have registered an increase in maximum temperatures. Changes in climatic norms of maximum August temperatures are presented in Fig. 2.25, which clearly shows the areas of decreasing maximum air temperatures localised in intensive irrigation areas (the Hunger Steppe, the Karshi Steppe, the Ferghana Valley and the valley of the Surkhandarya River). Average maximum temperatures have dropped by more than 1º C there, which is comparable to the natural variability of maximum air temperature at that time of the year.

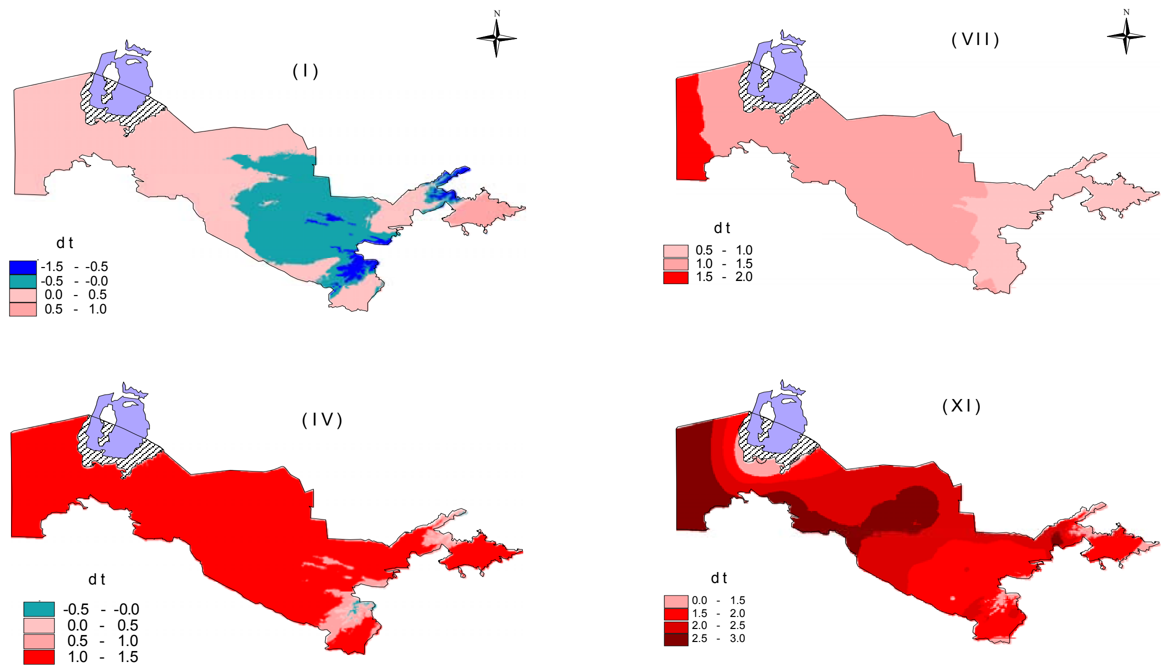


Fig. 2.24. Differences in climatic norms of average monthly minimum air temperatures in the two basic periods (1931 – 1960 and 1961 – 1990) in January, April, July and November.

Studies of the impact of irrigation on the microclimate of irrigated fields and surrounding territories have been conducted many times. According to the field data, average daily air temperature over cotton plantations may be 3.6º C lower than the air temperature over the surrounding desert territories. In the present paper standard month-averaged meteorological observations including the impact of irrigation on climatic conditions in sufficiently large areas have been used to assess changes

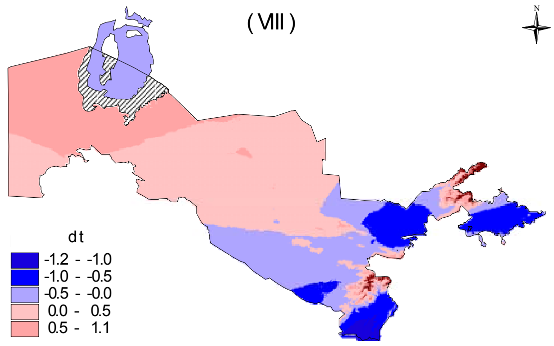


Fig. 2.25. Differences in climatic norms of maximum air temperatures in two basic periods (1961-1990 and 1931-1960) in August.

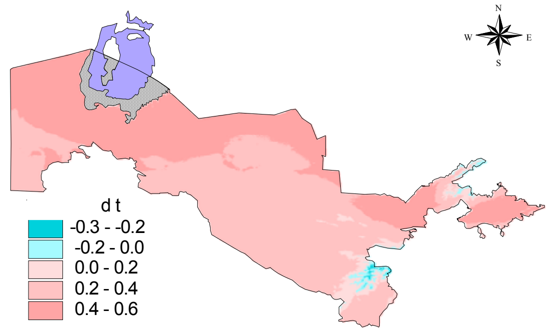


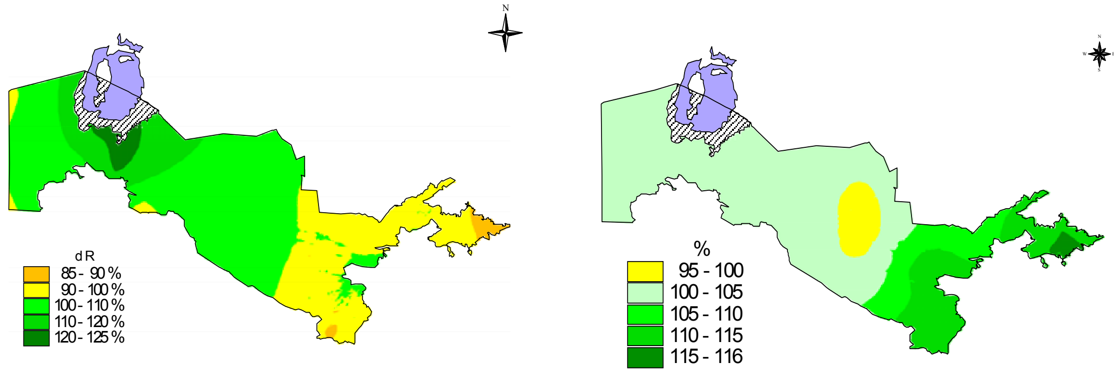
Fig. 2.26. Differences in the average annual air temperature in 1991-2000 and climatic norms of 1961-1990.

An analysis of changes in the air temperature of the past decade has shown that the tendency towards their increase persists. In 1991-2000 the average annual temperature proved to be higher than the benchmark norms practically throughout the entire territory of Uzbekistan (Fig. 2.26).

Table 2.10. Percentage of stations in Uzbekistan that have registered changes in the statistic parameters of average monthly air temperature
(1 – observed change, 2 – observed significant change)

Month	Dispersion				Average values			
	Increase		Decrease		Increase		Decrease	
	1	2	1	2	1	2	1	2
January	41.2	**8.8**	5.9	**5.9**	8.8	**5.9**	-	**-**
February	5.9	**2.9**	44.1	**11.7**	-	**-**	26.5	**23.5**
March	8.8	**-**	5.9	**2.9**	2.9	**2.9**	8.8	**5.9**
April	35.3	**20.6**	11.8	**-**	8.8	**5.9**	-	**-**
May	23.5	**11.7**	11.7	**8.8**	2.9	**-**	2.9	**2.9**
June	17.6	**11.8**	73.5	**61.8**	-	**-**	20.6	**8.8**
July	73.5	**58.8**	2.9	**2.9**	20.6	**2.9**	-	**-**
August	26.5	**20.6**	55.9	**47.1**	-	**-**	-	**-**
September	61.8	**58.8**	17.6	**5.9**	47.1	**23.5**	-	**-**
October	82.4	**55.9**	2.9	**-**	2.9	**2.9**	-	**-**
November	20.6	**11.8**	29.4	**20.6**	11.8	**5.9**	11.8	**11.8**
December	20.6	**5.9**	11.7	**2.9**	5.9	**5.9**	-	**-**

Precipitation. An assessment of precipitation changes has shown that after an analysis of monthly resolution series it is impossible to identify any significant change in climatic norms. The number of stations that have registered a significant increase and a significant decrease in precipitation does not exceed 23.5 per cent (see Table 2.10). It should be noted that an increase in average precipitation amounts are largely accompanied by an increase in both their temporal (greater dispersion) and territorial variability (some stations have registered both a significant increase and a significant decrease in precipitation in the same month).



a
Changes in climatic norms in two benchmark periods (1961-1990 and 1931-1960).

b
Ratio of average annual precipitation amounts in 1991-2000 to the norm of the benchmark period (196101990).

Fig. 2.27. Changes in annual precipitation amounts.

A comparison of average annual precipitation amounts and total precipitation in the cold and warm periods over the past 30 years has shown that by 1990 an increase in precipitation amounts had occurred only in the plains of Uzbekistan (see Fig. 2.27a) but it was statistically insignificant. Only some stations in the Aral Sea littoral area registered a considerable increase in precipitation (by 20-25 per cent). In the mountains and mountain foothills there are some places where precipitation amounts have either increased or decreased.

However, in the past decade (1991-2000) the average annual precipitation amounts proved to be higher than the benchmark norms in the mountains and mountain foothills (see Fig. 2.29b).

Thus, monitoring data of the past 70 years do not show any significant tendencies towards change in the precipitation regime in the territory of Uzbekistan.

2.3.4. Assessing the Probability of Climatic Extremes in Uzbekistan Related to Climate Change

At present the assessment of probability of climatic extremes in Uzbekistan is highly important for all economic sectors. The global warming has aggravated this problem further. The objective of the present paper is to assess possible extreme values of air temperature and precipitation in the territory of Uzbekistan in conditions of climate change.

Air temperature. A comparative analysis of repetition of major anomalies in air temperature has shown that there has lately been a tendency towards a decrease in the number of negative anomalies. Fig 2.28 presents temporal series of the abnormality index ($\Delta T_i/\sigma$, where ΔT_i is the anomaly of the year *I,* and σ is the root-mean-square deviation) computed in relation to the benchmark (1961-1990) norm based on the average annual air temperatures at stations having the longest monitoring series in Uzbekistan.

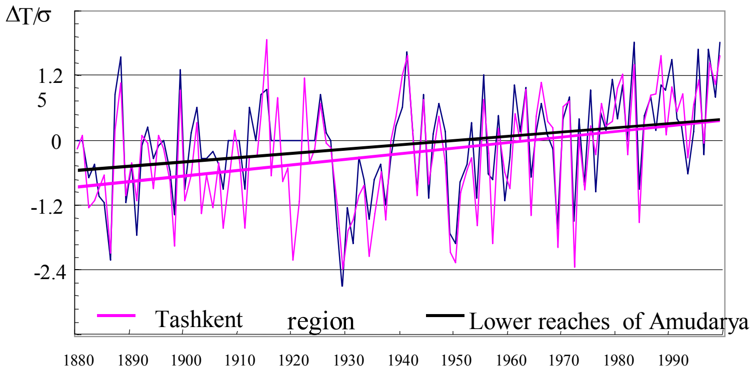


Fig. 2.28. Temporal course of the abnormality index in two regions in Uzbekistan.

It should be noted that variations of the average annual temperature are highly simultaneous throughout the territory of Uzbekistan. All major anomalies are simultaneously registered at stations situated in various parts of Uzbekistan, and the values of the index are almost the same both in Tashkent region and in Urgench (the lower reaches of the Amudarya River). Therefore, an analysis of repetition of extreme annual anomalies registered at some stations may serve as a basis for conclusions relating to the entire country's territory.

Table 2.11 presents repetitions in the number of positive and negative anomalies (in relation to the average of the entire monitoring period) of the average annual air temperature registered at the Tashkent station within different periods of time as well as the repetition of large (>σ) and extra large (>1.5 σ) anomalies. After 1940, an increase in the number of positive anomalies and a considerable decrease in the repetition of negative anomalies have been registered.

Table 2.11. Repetition (percentage) of the number of extreme anomalies of average air temperature at the Tashkent station in different periods

Period	Positive anomalies			Negative anomalies		
	$\Delta T>0$	$\Delta T>\sigma$	$\Delta T>1.5\sigma$	$\Delta T<0$	$\Delta T<-\sigma$	$\Delta T<-1.5\sigma$
1881-1940	38.3	6.6	1.7	71.7	31.6	10.0
1941-2000	62.7	13.3	1.7	38.3	13.3	8.3

Repetition of very large positive anomalies has not changed, it has remained very low (1.7 per cent) while repetition of very large negative anomalies has remained relatively high (8.3 per cent). The total number of extremes has decreased mostly due to a reduction in the number of negative anomalies.

Table 2.12. Average values and root-mean-square deviations (σ) of the average annual air temperature at the Tashkent station during different 30-year periods

Statistical characteristics	Periods			
	1880-1909	1910-1939	1940-1969	1970-1999
$\bar{x}$	13.2	13.2	13.6	14.3
σ	0.62	0.81	0.85	0.69

Based on the data of stations with the longest monitoring series, temporal changes in the root-mean-square deviations have been assessed. A decrease in variability of the average annual air temperature was registered in the past 30-year period (1970-1999). However, this cannot be regarded as an impact of the global warming because similar or even lower values of the root-mean-square deviations were registered in earlier periods (see Table 2.12).

Thus, conditions of climatic scenarios should be based on the values of the root-mean-square deviations corresponding to the period of higher temperatures and including both extremely warm and extremely cold years. The benchmark climatic period of 1961-1990 meets these conditions.

Precipitation. An analysis has shown lack of unequivocal tendencies in the repetition of extremely moist and dry years registered by stations situated in Uzbekistan. It is common knowledge that precipitation in Uzbekistan is connected with cold fronts, intrusion of southern cyclones and air currents in the mountain foothills. Heavy rainfall (over 200 mm per day) rarely occurs on large territories simultaneously. In 77 per cent of all cases heavy rainfall is registered by only one or two stations. At many stations of Uzbekistan such rainfall is practically comparable to monthly norms, and considerably exceeds it during warm seasons. Thus, a conclusion suggests itself that these rare monthly precipitation extremes are incidental. Such extreme anomalies in monthly precipitation amounts may occur in periods of both excessive and deficient rainfall.

All stations of Uzbekistan in practically all months note the following tendency: in case of an increase in the average amounts of precipitation their variability also increases. This means that the probability of extreme phenomena in the humidity regime rises. This tendency is a result of a considerable positive asymmetry in precipitation distribution. Thus, if any increase in precipitation takes place in the future, it may be assumed that the number of extremely moist and extremely dry years in Uzbekistan will increase as well.

Methodology for estimating possible extreme values. Empirical quantiles of 10 and 90 per cent probability were used to estimate the extremity of monthly air temperatures and monthly precipitation amounts. The above quantiles were computed for the conditions of climatic scenarios with the application of theoretical distribution functions. Climatic scenarios give only an estimate of average measurements. As regards dispersion an assumption was made about its correspondence to the benchmark period of 1961-1990.

The parameters of distribution of probabilities of the average monthly, minimum and maximum air temperatures as well as monthly and seasonal precipitation amounts were computed and analysed over a 50-year period (1949-1998). A conclusion was made about the need to consider the asymmetry of distribution of minimum and average monthly air temperatures in winter months, and a possibility was shown of applying a generalised normal distribution with a correction for asymmetry as a theoretical function of distribution. For the approximation of the distribution function of the monthly precipitation amounts Pearson curve type III has been chosen.

Estimating possible extreme values of air temperature. IPCC documents point out that the rise in temperature expected in Central Asia in the next two decades will be within the limits of 1º or 2º C. Considering the natural monthly variability in different seasons of the year, an option of a 2º C increase in the average winter temperature and a 1º C increase in the average summer temperature throughout the entire territory of Uzbekistan has been considered in estimating possible extreme air temperature values.

Fig. 2.29(a) presents a distribution of 10 per cent probability empirical quantiles of the average monthly air temperature in January, and Fig. 2.29(b) presents the same value computed for conditions of a 2º C increase in the average air temperature throughout the territory of Uzbekistan.

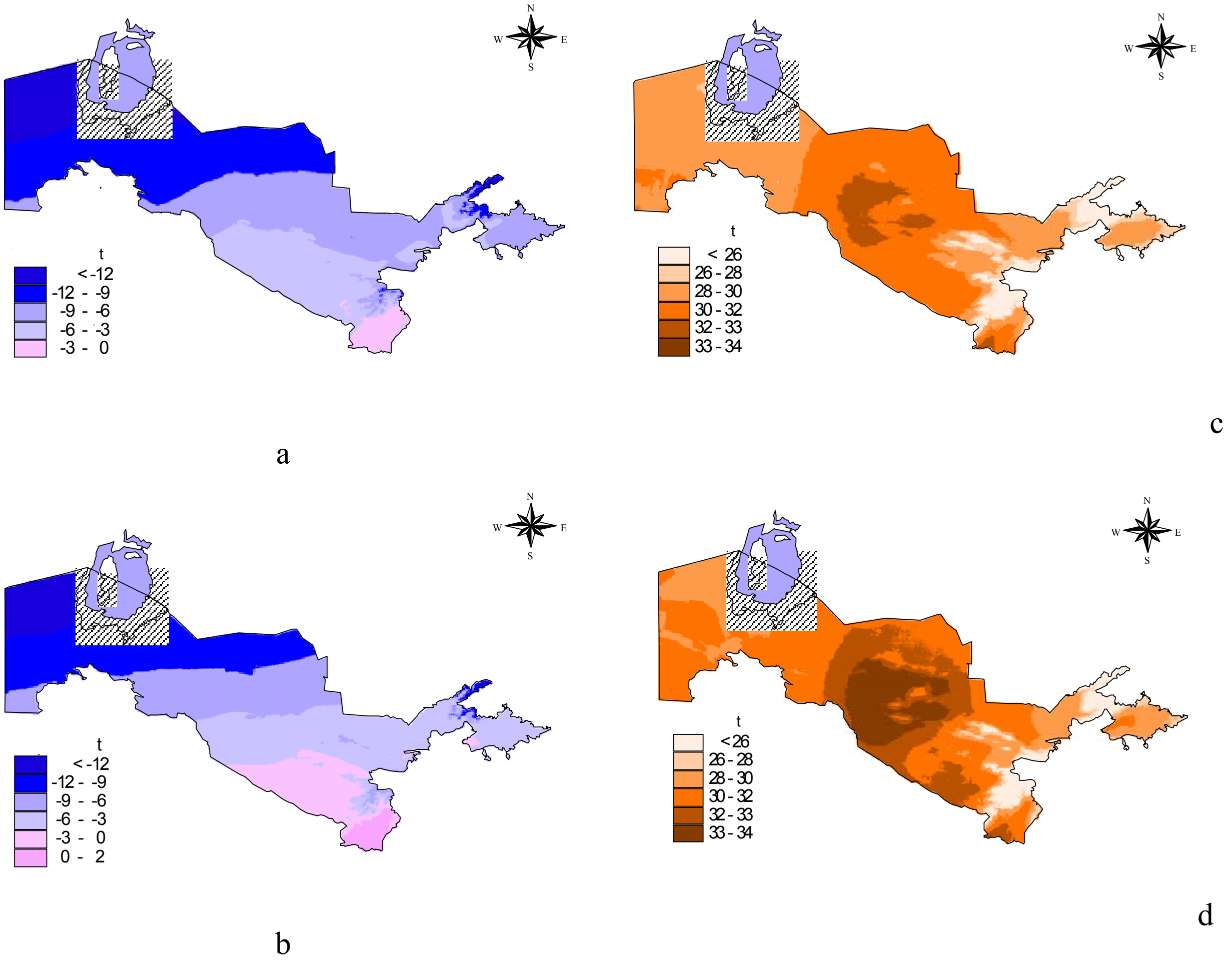
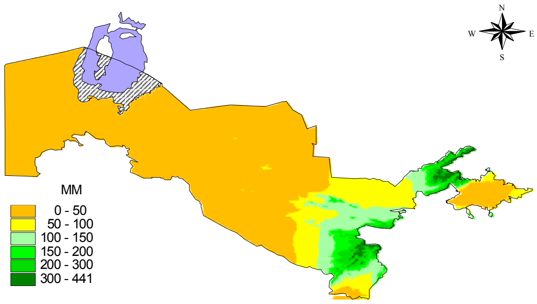


Fig.2.29. Empirical (a, b) and estimated for conditions of climatic scenarios(c, d) low and high average monthly air temperatures (º C) in January and July. (b – 2º C increase in January norms, d – 1º C increase in July norms).

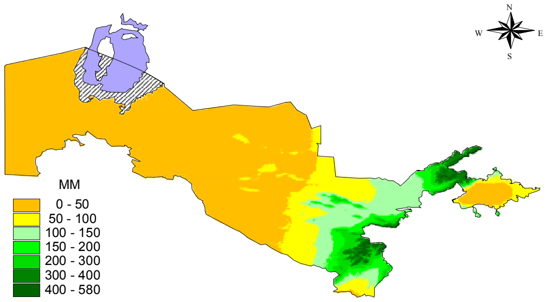
Both at present and in case of an increase in temperature there will remain a probability of very low average monthly air temperatures in the northern and central parts of the country. This is a consequence of a high natural temperature variability in winter in those parts of Uzbekistan.

The northern part of the Kyzylkum desert where significant negative anomalies may occur in case of a rise in temperature is also referred to the maximum climatic variability zone. As for the rest of the country, possible negative anomalies in case of a rise in temperature will be less significant, especially in the Ferghana Valley and the Surkhandarya River valley.

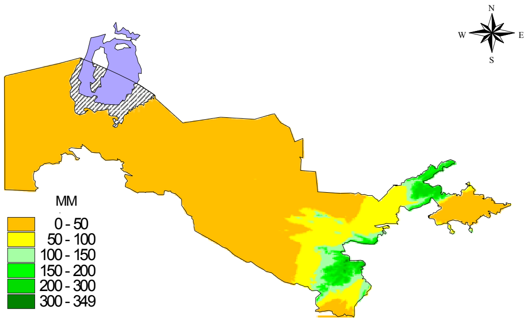
Fig. 2.29 (c, d) presents the distribution of values of 90 per cent probability empirical quantiles throughout the territory and possible values in conditions of the July climatic scenario. The figures clearly show expansion of the areas where extremely high average monthly air temperatures are probable.



a

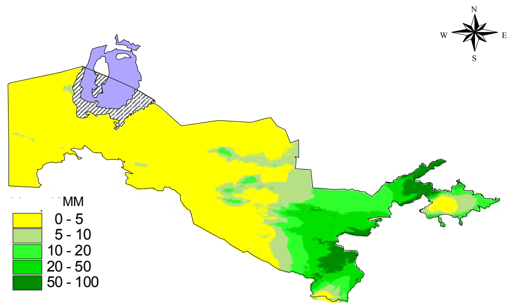


b

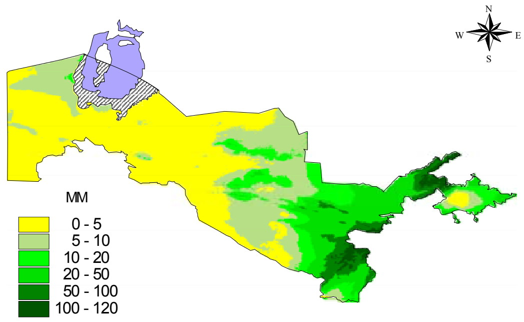


c

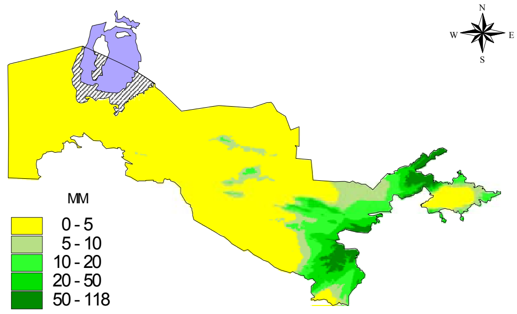
Fig. 2.30. **Annual precipitation amounts at 90 per cent probability (a – empirical, b – estimated for 10 per cent precipitation increase scenario, c – estimated for 10 per cent precipitation decrease scenario).**



a



b



c

Fig. 2.31. **Precipitation amounts in April and May at 90 per cent probability (a - empirical, b – estimated for 10 per cent precipitation increase scenario, c – estimated for 10 per cent precipitation decrease scenario).**

While at present such temperature regime is characteristic only of some desert areas, in case of a temperature increase (even by 1º C) this zone will embrace a considerable territory, and therefore a probability of very high maximum temperatures will increase as well.

Under the climatic scenario conditions an expansion of the zone of high maximum temperature will be conducive to thermal stress in agricultural animals and people working in the open. This example stresses the need for generating scenarios of changes in maximum and minimum air temperatures in the territory of Uzbekistan. Such scenarios may be used for assessing the impact of climate change on people's health and productivity of livestock, crops and natural pastures.

Estimating possible extreme precipitation amounts. To this day estimates of possible changes in precipitation have been very uncertain. In the present paper are presented estimates of possible extreme values of a given probability in the event of both a 10 per cent increase in precipitation and its decrease.

An analysis has shown that between 90 per cent empirical quantiles (annual precipitation amounts with a 10 per cent probability) and the values computed for the conditions of the climatic scenario of a 10 per cent increase in precipitation there are few differences as regards their territorial distribution. As regards the zone of foothills and mountains, localisation of ranges of possible extreme precipitation amounts remains. In the event of a 10 per cent increase in precipitation amounts, apart from the expansion of the area with less than 240 mm of precipitation, there occurs a considerable reduction in the area with the maximum annual precipitation of 600 to 700 mm.

Obviously, a 10 per cent reduction in the annual precipitation will have a greater impact on Uzbekistan than its increase. Fig. 2.30 presents empirical quantiles of 10 per cent probability (90 per cent probability of precipitation) and estimates of their change for the scenarios of both 10 per cent increase and decrease against the benchmark. In the event of a decrease in precipitation throughout practically the entire territory of Uzbekistan including the mountains extremely low annual precipitation amounts will be observed.

However, to identify the negative after-effects of a change in the precipitation regime it is more important to review separate seasons of the year. For instance, to estimate the extent of moisture availability on natural pastures an estimate of moisture availability in spring months is important.

Fig. 2.31(a) illustrates the distribution of precipitation amounts of 90 per cent probability (10 per cent empirical quantile) in April and May. It is clear that the entire pasture area falls into the range of 0 – 5 mm. Pasture vegetation may perish under such conditions.

A 10 per cent increase in precipitation in April and May (see Fig. 2.31(b) has practically no impact on the probability of extreme precipitation shortage in the plains of Uzbekistan (the area of desert pastures). This zone both at present and in the event of a 10 per cent increase in precipitation remains a risk area due to climatic variability in moisture availability. The rain-fed farming zone is also within the risk area.

For rain-fed farming it is highly important to know precipitation probability at various times during vegetation period for different crop varieties and sowing dates. In future precipitation of different probability should be computed for different scenarios considering crop requirements to moisture availability.

2.3.5. Statistical Interpretation of Outputs of General Circulation Models for Generating Regional Climatic Scenarios

Global general circulation models (GCM) may serve as the most suitable basis for generating regional climatic scenarios. However, the output data obtained with the help of GCM have a low spatial resolution. To generate regional climatic scenarios statistical interpretation methods are required, which will transform the GCM output data into meteorological parameters with the required spatial and temporal resolution.

Methodology for generating climate change scenarios based on the concept of 'ideal forecast'. One of the approaches to developing the statistical interpretation method is the 'ideal forecast' concept, when statistical links are found in the diagnostic data but applied to the GCM output data. In this case the quality of interpretation improves with the improvement of the model.

To this end archives of each climatic parameter should be created in the grid nodes based on the monitoring data that should be viewed as predictors, while the actual monitoring data obtained at stations should be viewed as predictants. A specialised archive of predictors has been created within the framework of the present paper in the grid nodes based on the monthly resolution data supplied by all the stations existing in the territory under review.

In developing this method the authors of the paper were guided by the MAGICC/SCENGEN system (Version 2.4). At present the data with a resolution of 5x5º can be interpreted for the territory of Uzbekistan. In the MAGICC/SCENGEN system there are output data of 21 GCM for all scenarios of IS92 emission including the contribution of sulphate aerosols.

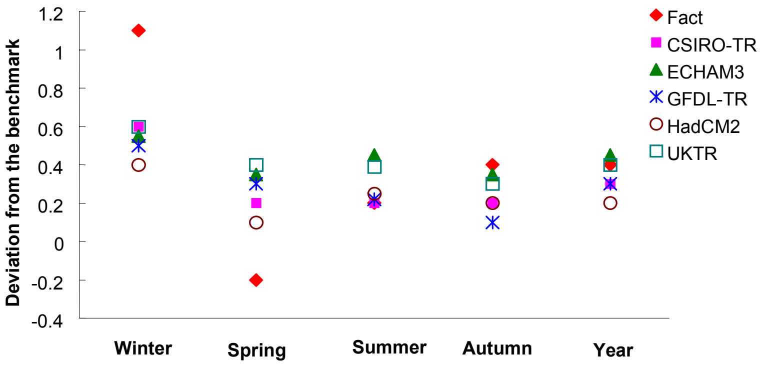


Fig. 2.32. Comparison of actual anomalies of average air temperature in 1991-2000 with the outputs of statistical interpretation for Tashkent station for 1986-2015.

To assess the outputs obtained with the help of the developed method, statistical interpretation of the outputs of some models was carried out for the Tashkent station for the period of 1986-2015, and actual deviations from the average temperature benchmark for the period of 1991, which may be regarded as an independent sample, were computed (see Fig. 2.32). It should be pointed out, that the model estimates correlate well with he actual anomalies for summer, autumn and the whole year, and tendencies of air temperature variations in the past decade are well described by the models.

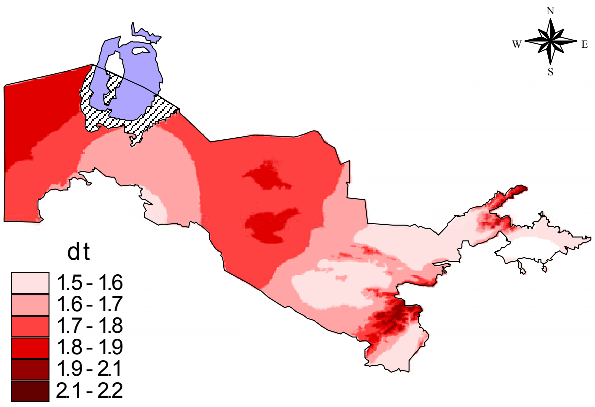


Fig. 2.33. Statistical interpretation of the outputs of ECHAM3 model (average annual air temperature) for the year 2050 in conformity with the IS92 emission scenario and with due regard for the impact of sulphate aerosols.

The developed method permits to obtain a detailed territorial scenario and consider regional peculiarities. An example is presented in the form of a map of average annual air temperature variations in the territory of Uzbekistan based on the statistical interpretation of outputs of the ECHAM model for the year 2050 under the scenario of IS92 emission and considering the impact of sulphate aerosols (see Fig. 2.33). Similar maps can be made for individual months and seasons.

Of course, application of temporal series of the actual control model runs for building equations is preferable, but this method will be good for the given model at a fixed moment of its development. The approach proposed above results in a more universal methodology, which is based on dependencies built on the actual monitoring data registered by stations.

The 'ideal forecast' concept may be applied to developing scenarios of changes in different climatic parameters that are not GCM outputs. The authors of the paper have assessed a possibility of applying the outputs of monthly resolution models for obtaining scenarios of changes in agro-climatic resources of Uzbekistan (such as the sums total of effective temperatures and dates of sustainable transition of average daily temperature across the set limits). Statistical links between the smoothed series of average monthly air temperatures and agro-climatic resource indicators proved to be very close; their multiple correlation ratios reach as high as 0.80 – 0.96. In future this approach may be used for generating scenarios for other climatic parameters.

Methodology for generating climate change scenarios based on the MOS concept. The main principle of the MOS (Model Outputs Statistics) concept is the application of statistical links obtained as outputs of specific models. That is prognostic equations are built on the basis of model data obtained as a result of reproduction of actual climate by the model. This approach permitting to take into consideration systematic errors of the model has, however, one significant shortcoming, namely, the need to create archives of control runs of sufficient length in case of any modification in the basic model.

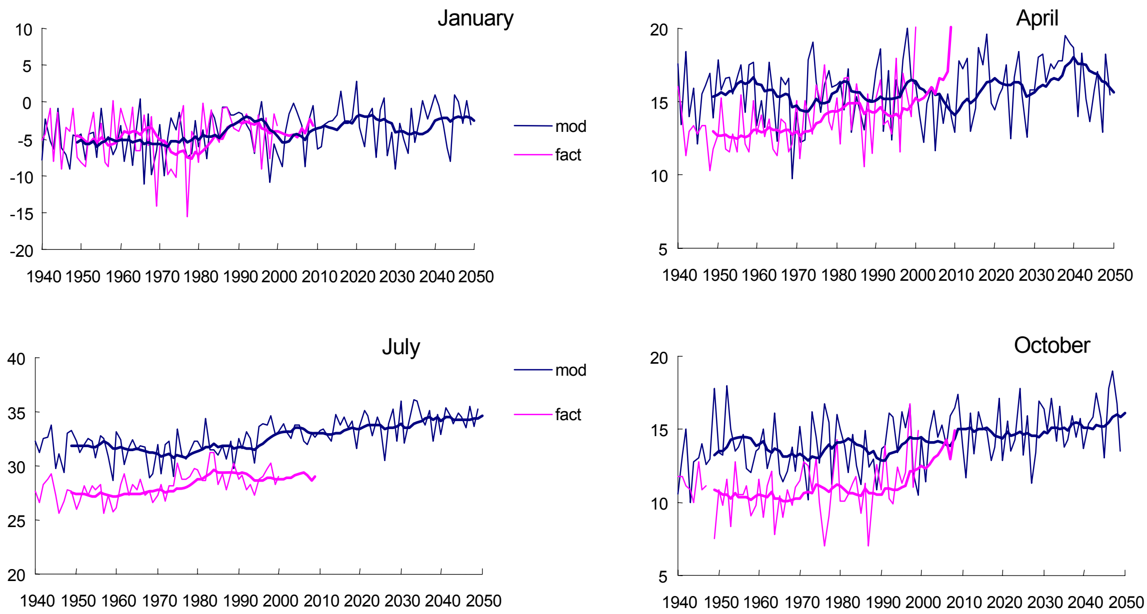


Fig. 2.34. Comparison of actual air temperature (ºC) at Nukus station (fact) and model data in the geographically closest point (mod), input series and 10-year sliding averages.

When generating climatic scenarios for Uzbekistan in the present paper, the MOS concept was applied on the basis of outputs of the ECHAM model taking into consideration the mitigating impact of sulphate aerosols. The outputs are monthly resolution values for the period of 1940 through 2049 at grid nodes (2.8ºx2.8º) throughout the territory of Central Asia.

Low correlation ratios between the values at grid nodes that are MOS outputs and the monitoring data of the stations do not permit to build prognostic equations directly to be used in the development of climatic scenarios. Therefore smoothed temporal series have been used as predictors and predictants in building equations.

Fig. 2.34 illustrates the temporal course of air temperature in the middle months of the seasons at the Nukus station and model temperature series in the geographically closest point of the model grid (input series and 10-year sliding averages). An analysis has shown a number of systematic errors, exclusion of which is the aim of statistical interpretation.

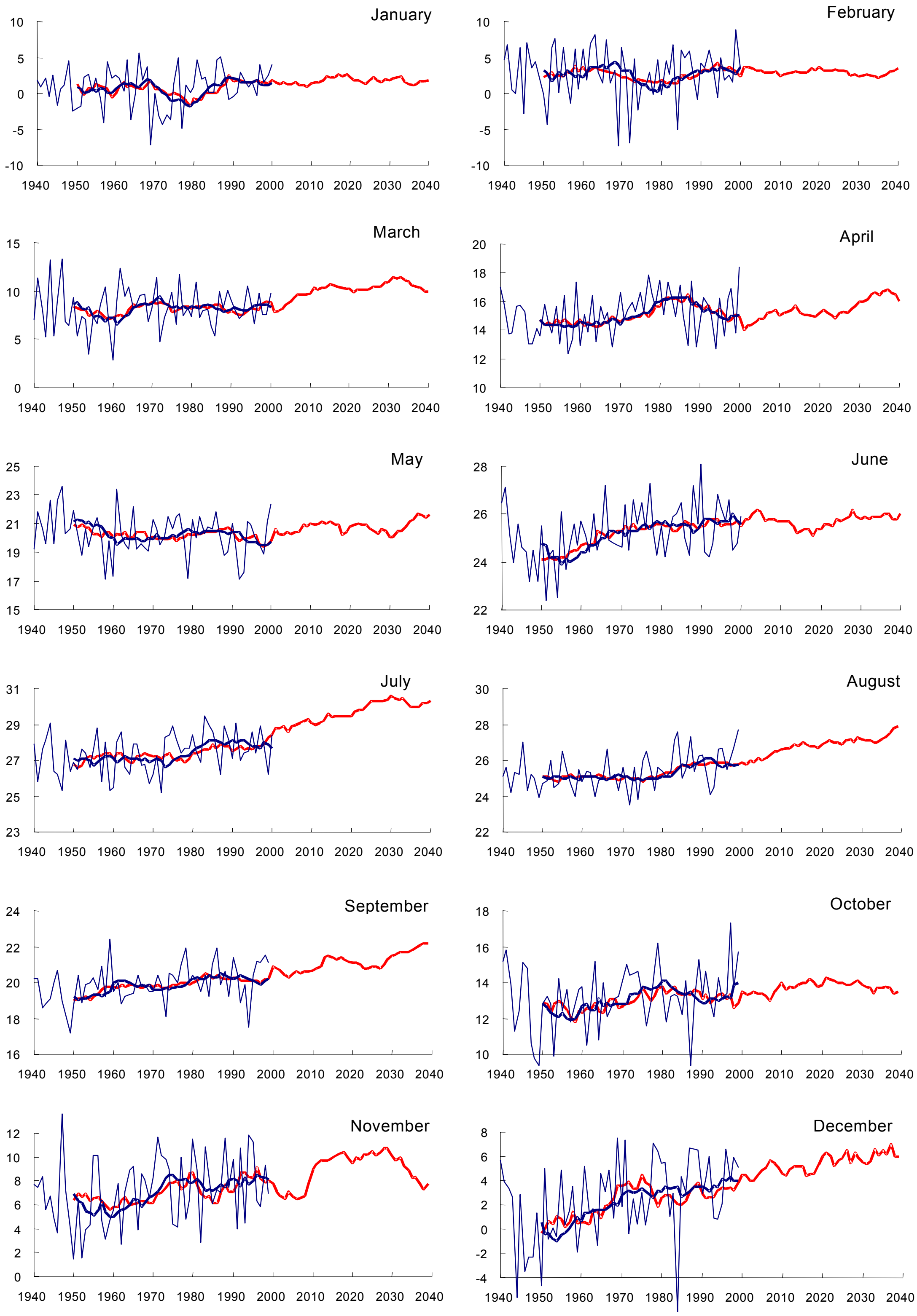


Fig. 2.35. Comparison of results of interpretation of ECHAM model output data with the actual values of air temperature (ºC) at Tashkent station and the generated scenario .

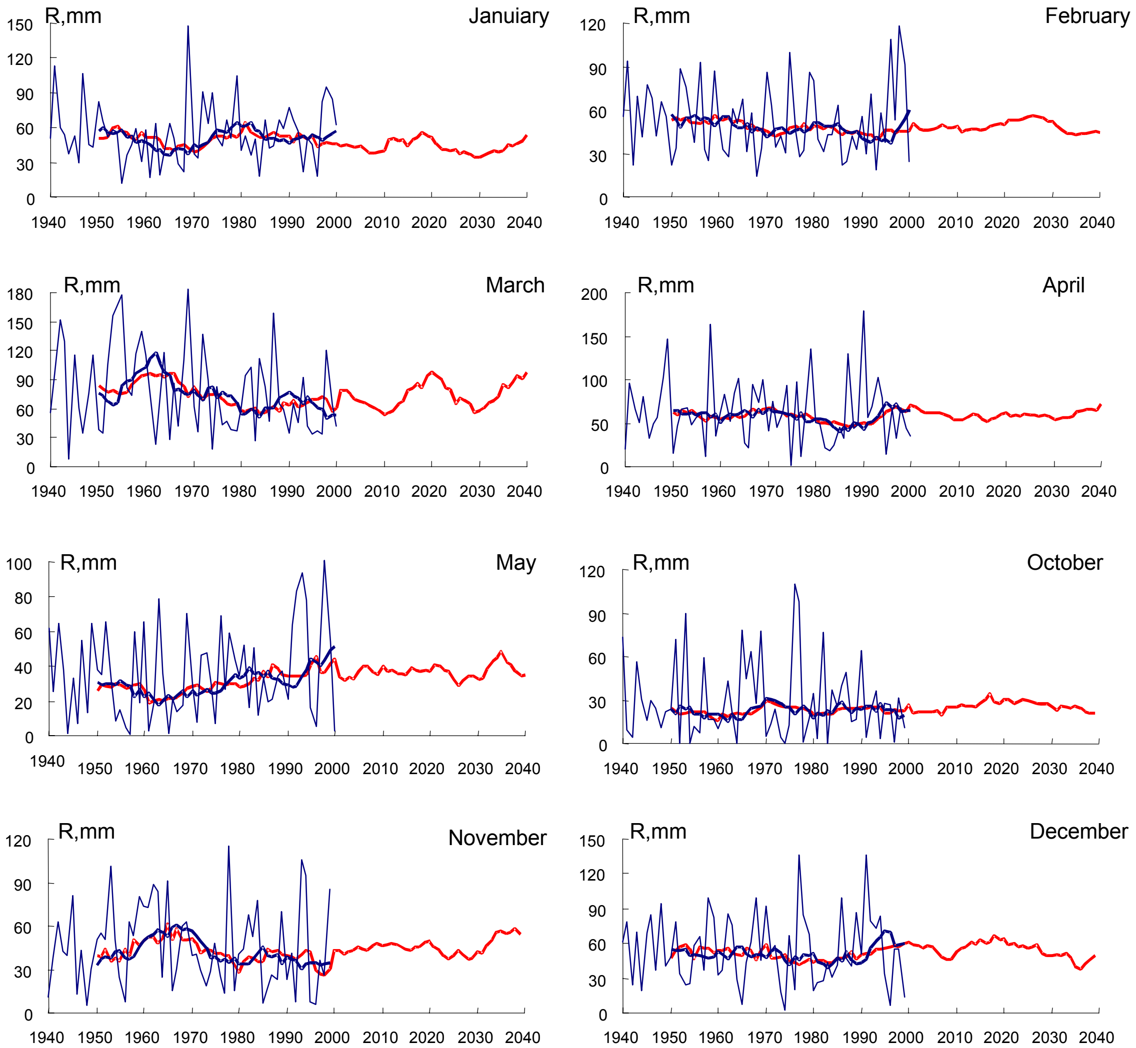


Fig. 2.36. Comparison of results of interpretation of the ECHAM model output data with the actual values of monthly precipitation amounts registered at the Tashkent station.

The developed method of statistical interpretation is based on a stepped multiple linear regression; check has been carried out using the sliding control technique. The above method was used for plotting a climate change scenario for Tashkent station (see Fig. 2.35). The estimates of smoothed air temperature series obtained on the basis of the above method practically coincide with the 10-year sliding average instrumental monitoring series for all months. This means that the quality of actual data restoration is sufficiently high. The scenario generated for 40 years permits to conclude that the average monthly air temperature at the Tashkent station will rise in most months by the year 2040.

Fig. 2.36 presents a comparison of results of the interpretation of the ECHAM model output data as regards the Central Asian territory with the actual values of precipitation amounts as registered at the Tashkent station and a plotted scenario of changes in precipitation sums total. It is clear from the diagrams that the testing of the statistical interpretation method by an independent sample (sliding control) has a sufficiently high extent of justification. A scenario for monthly precipitation sums total based on the MOS concept shows their insignificant change by 2040.

2.4. Study of Integrated Climatic Indicators, Assessment of Possible Negative Consequences

2.4.1. Climate Change and Mudslide-Prone Areas in Uzbekistan

The study of the climate change impact on the extent of mudslide hazards includes this:

- identifying current risk zones (mudslide-prone areas);
- identifying the genesis of mud slides and their dynamics with regard to climatic factors;
- undertaking a probability assessment of mudslide-forming precipitation;
- assessing the scale of mudslides throughout the territory;
- assessing possible dynamics of mud slides in connection with climate change in the region;
- identifying adaptation interventions in mudslide-active areas.

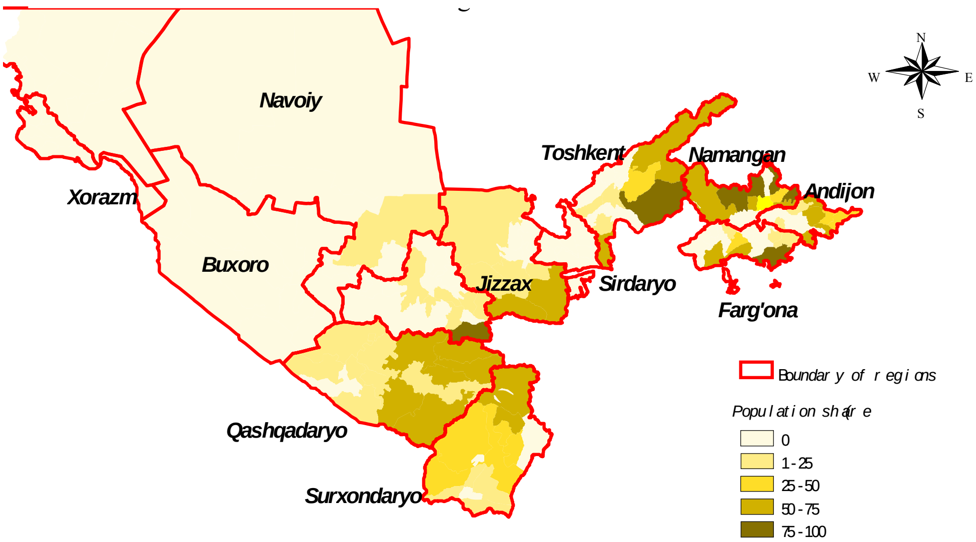


Fig. 2.37. Share of population living in mudslide-active zones of Uzbekistan.

Mountains and partially foothills of Uzbekistan are regarded as mudslide-prone areas, and those where mudslides are very active occupy approximately 12 per cent of the country's area. The population share living in the mudslide-active areas is presented in Fig. 2.37.

The data on mudslides that occurred in Uzbekistan date back to 1874, and the mudslide register contains information on 241 most mudslide-dangerous waterways. However, all the waterways including small and drying up rivers situated in the mountains of Uzbekistan can be regarded as mudslide-dangerous. The overwhelming majority of mudslides are formed as a result of intensive liquid precipitation (see Fig. 2.38). However, causes of mudslide formation may be diverse such as intensive melting of snow in the mountains, breakthrough of alpine and glacial lakes, earthquakes, landslides, landfalls, etc.

Dynamics of low-mountain mudslides mostly depends on changes in liquid precipitation amounts, and that of high-mountain mudslides depends on changes in air temperature in the warm seasons of the year. There were cases of mudslides of human-induced nature such as the breakthrough of mudslide storage reservoirs, blockage of riverbeds by mountain rock heaps, etc. According to multi-annual data, practically the entire year is mudslide-dangerous in Uzbekistan, the most dangerous period being April to June (see Fig. 2.39).

Often several mudslides pass down the rivers of Uzbekistan in the course of the year. The largest number of mudslides that occurred during one year was registered in the Tupolang River (8 cases), 7 cases in the Gawasai River, 6 cases in the Kasansai and Padshata rivers and 4 cases in the Isfara, Soh, Shakhimardan and Isfairisai rivers each.

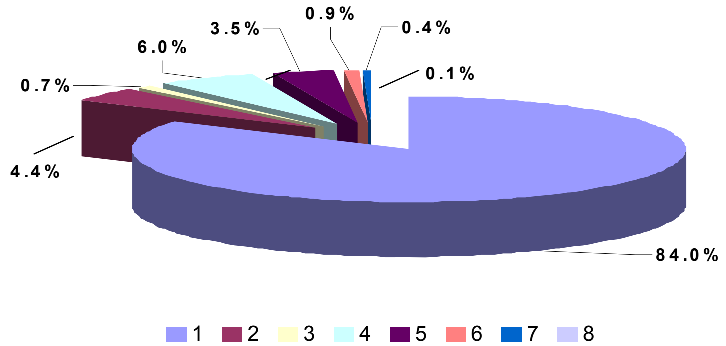


Fig. 2.38 **Causes of formation of mudslide flow in Uzbekistan (1 – rainfall, 2 – rainfall with hail, 3 – hail, 4 – snow melting, 5 – snow melting with rainfall, 6 – breakthrough of dams, 7 – breakthrough of glacial lakes, 8 – other causes).**

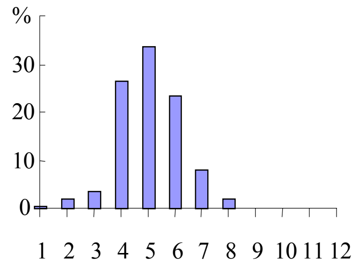


Fig. 2.39. **Intra-annual distribution of mudslides in Uzbekistan.**

Since mudslides are mostly connected with intensive rainfall forming the maximum water flow in rivers, mudslides are frequent also in dry years. Dry years account for an average of 2 per cent of mudslides throughout the country.

An analysis of changes in the maximum annual flow has shown an increasing danger of mudslides on waterways in Uzbekistan. For 67 per cent of rivers a substantial positive trend in the maximum water flow has been computed, for 13 per cent an insignificant trend and only for 13 per cent of the studied rivers the trend of maximum flow is negative.

For purposes of mudslide danger assessment in case of climate change, dependence has been traced between maximum daily amounts of liquid precipitation in a year and the fact of formation (1) or non-formation (0) of a mudslide flood in the given year. The extent of dependence was characterised by the 'point-biserial' ratio of K. Pearson correlation. The order of changes in daily amounts of liquid precipitation was assumed the same as for changes in the annual precipitation, namely 5, 10 and 25 per cent. The number of rains per year changes within the same limits as does the repetition of mudslides originating from rainfall in case of the given climate changes. Estimates of mudslide repetition computed on the basis of this methodology for 17 waterways of Uzbekistan have shown sufficiently good correspondence to the facts of mudslide formation. The average mudslide repetition ranges between 1 and 3 cases in a decade.

It has been computed in the course of the assessment that in the event of a 20 to 25 per cent rise in the annual precipitation the average number of mudslides in a decade will increase by 15 to 19 per cent.

It should be noted that mudslides formed as a result of intensive snow melting and breakthrough of glacial lakes depend, apart from seasonal and multi-annual snow and ice reserves, on summer air temperatures. Therefore a rise in summer temperatures in the region will lead to increased mudslide danger and their greater number due to higher intensity of snow and ice melting in the mountains. Probably, the 1998 mudslide flood on the Shakhimardan River is a confirmation of this conclusion.

It should be pointed out that even in case of unchanged precipitation amounts the rise in air temperature expected in future will lead to an increase in the share of liquid precipitation in the annual sum total. This, in its turn, will increase the frequency of mudslides and expand the mountainous area prone to mudslides originating from rainfall.

According to assessments a 2º C rise in the average annual temperature will increase the average number of mudslides originating from rainfall by 6 per cent against the current figures.

A combined 20 to 25 per cent increase in the annual precipitation and a 2º C rise in air temperature will lead to a 20-25 per cent increase in the number of mudslides originating from rainfall as compared to the current average for the decade.

The undertaken studies have permitted to draw the following conclusions:

- even a small increase in annual precipitation amounts will lead to an increase both in the amounts and the number of annual rainfalls;
- an increase in the number and amount of rainfall will result in higher maximum flows and repetition of mudslides;
- in the event of unchanged precipitation amounts in future a rise in air temperature will lead to a higher share of liquid precipitation and higher mudslide danger in the territory.

Mudslide control interventions may be divided into preventive intended to change mudslide formation conditions and hydro-technical ones aiming to reduce the maximum mudslide flows and 'clarify' them, i.e. to reduce their thickness. The formers mostly consist of afforestation interventions on mountain slopes intended to reduce soil erosion and improve its infiltration properties. These interventions are time-consuming and require a sufficient input of funds and labour.

Hydro-technical interventions of mudslide control include stabilisation of mudslide-carrying riverbeds, diversion of mudslides from facilities requiring protection, retention and collection of mudslide masses and protection of facilities against the shock impact of mudslides.

Interventions improving security of people living in mudslide-prone areas and facilities situated include economic and logistical ones. First and foremost, they include stringent control over construction in mudslide-prone areas. Population growth in the country including its mountainous areas and the need to build irrigation systems make people settle down in the river floodplains and alluvial fans as well as in land- and mudslide-prone parts of river valleys. These territories have lately been used for recreation purposes, although this poses additional danger to human life.

2.4.2. Dynamics of Aridity in the Territory of Uzbekistan Related to Climate Change

Human use of lands in arid areas (animal husbandry as well as rain-fed and irrigated farming) intensifies natural processes of land degradation many times over. Such factors as drought and human-induced changes (the existing irrigation techniques and the global warming) are inter-related, which fact increases their negative impact.

The objective of the present study was to quantify changes in parameters determining the extent of aridity in the territory of Uzbekistan in connection with climate change. To assess the impact of climate change on the extent of aridity in Uzbekistan the following humidity rate has been selected: $K_{moist}=P/E$, where P is the annual sum total of precipitation in millimetres and E is the annual evaporation rate. Monthly evaporation has been computed according to the formula of N.N. Ivanov with the correction of L.A. Molchanov for conditions prevailing in Uzbekistan. Based on meteorological data of 50 climatic stations of Uzbekistan humidity rates have been computed for two 30-year periods (see Fig. 2.40). No temporal variations in humidity rates have been detected. This stability is explained by lack of any significant trends in the temporal series of annual precipitation amounts and their great natural variability throughout the territory of Uzbekistan.

For purposes of climatic assessment of temporal changes in aridity in the country's territory, annual evaporation rates in two 30-year periods have been estimated in the present paper (see Fig. 2.41).

An analysis of variations of the computed parameter throughout the territory has permitted to identify certain peculiarities. It has revealed an increase in possible evaporation in the Aral Sea littoral area and the greater part of the plains, including the plains in the Ferghana Valley. A decrease in possible evaporation has been noted in the Kashkadarya River Valley, which may be an effect of irrigation (see Fig. 2.41).

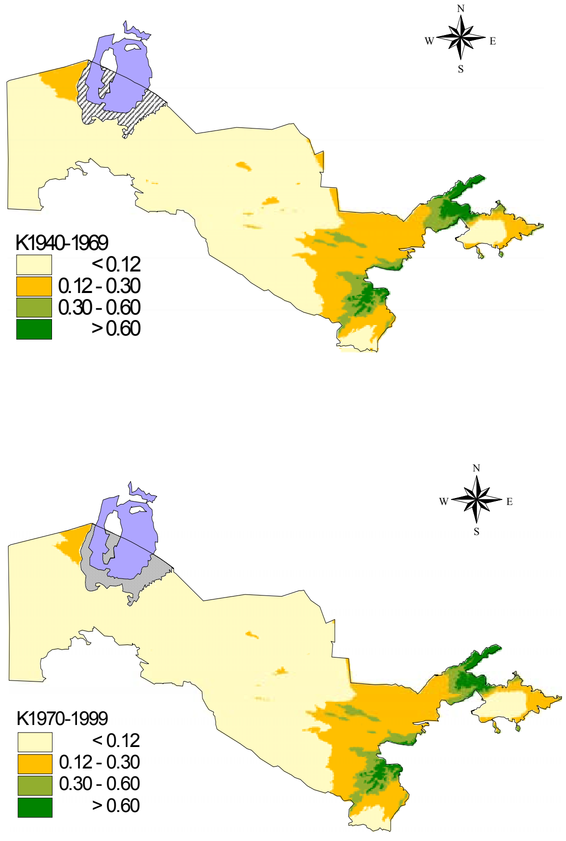


Fig. 2.40. Distribution of humidity rates throughout the territory of Uzbekistan in different 30-year periods.

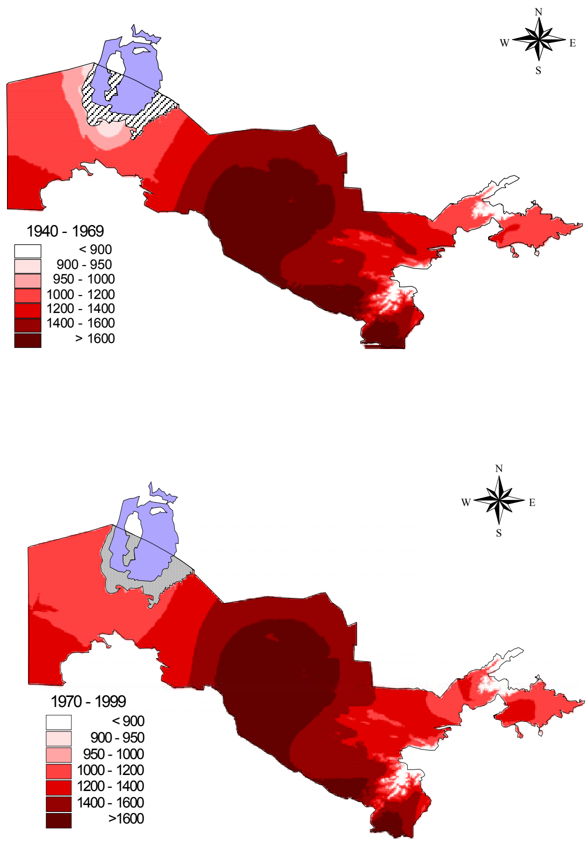


Fig.2.41 Distribution of evaporation rates (mm) throughout the territory of Uzbekistan in different 30-year periods.

If viewed by seasons, evaporation may substantially increase during drought.

Drought indexes. For purposes of climatic assessment of changes in aridity in Uzbekistan, the present study has reviewed the following drought indexes: *SPI* – Standard Precipitation Index (anomaly as percentage of the norm); *D* – air humidity deficit; *E* – evaporation; and *S* – standard drought index of D.A. Ped (the difference between temperature anomalies normalised per standard deviation and precipitation).

Changes in aridity in the territory of Uzbekistan. All drought indexes are computed on the basis of average monthly data of meteorological stations characterising various parts of the territory of Uzbekistan.

Fig. 2.42 presents series of the normalised precipitation index (March through May) computed for stations in mountain foothills (Tashkent, Ferghana), lower reaches of the Amudarya River (Urgench) and the desert area (Tamdy). In the foothills of Uzbekistan strong drought (*SPI*> -50) is observed in spring from one to three times in a hundred years, while drought with a 20 to 25 per cent deficit in seasonal precipitation amounts is a regular occurrence observed once every three or four years.In the desert and semi-desert areas very strong drought (*SPI*. –50) occurs once every ten years on the average, while drought with a *SPI* of <-20 occurs twice as frequently. It should be noted that the spring months of 1995 and 1996 were characterised by extreme drought.

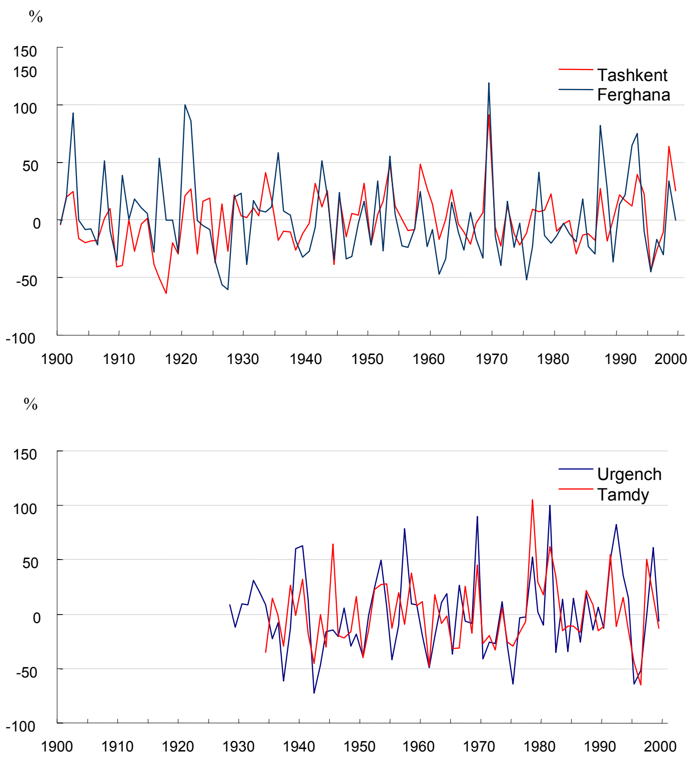


Fig. 2.42. Changes in the normalised precipitation index at some stations in Uzbekistan (spring months).

However, no tendency towards any long-term changes in this drought indicator is observed either in mountain foothills or in the plains of Uzbekistan. Therefore, the standard precipitation index is not susceptible to climate change in the given region.

In order to reflect the human-induced impact on the humidity regime, six stations have been selected for purposes of the present study. The Nukus station monitors the irrigated lower reaches of the Amudarya River. The Tamdy station monitors the central part of the Kyzylkum desert. The Tashkent station monitors the mountain foothills, an area with the strongest impact of urbanisation. The Jizzak station monitors the Hunger Steppe, a region of an accelerated increase in the area of irrigated land over the past decades, and the Chimbai and Muinak stations characterise conditions in the Aral Sea littoral area. Muinak was formerly situated near the shoreline. Fig. 2.43 presents diagrams of changes in the average air humidity deficit at the selected stations in autumn.

Although the Nukus station is situated near irrigated tracts of land, the tendencies in humidity deficit changes are similar to those observed at the desert station in Tamdy. A tendency towards humidity shortage has also been traced at the Tashkent station. The Jizzak station has registered the human-induced impact on humidity change, which manifests itself in a decrease of humidity deficit due to an increase in irrigated areas. The stations in the Aral Sea littoral area unequivocally register an increasing humidity deficit as the shoreline recedes, and greater variations in all seasons. Noticeable changes in the uniformity of observation series related to the Aral Sea regression (Chimbai and Muinak) are clearly seen in the figure.

Thus, humidity deficit is a drought indicator very susceptible to climate change. In absence of any strong local human-induced impact this indicator confirms tendencies towards aridity increase in the autumn and summer seasons throughout the territory of Uzbekistan.

In this connection it is interesting to review such an indicator of drought as evaporation rate by seasons of the year. The formula for calculating evaporation rate includes average monthly values of both air temperature and humidity, therefore the calculated value may serve as a criterion of temporal changes of possible evaporation under the given meteorological conditions. Average evaporation values have been computed for different seasons in two 30-year periods (1940 – 1969 and 1970 – 1999) based on the data of 50 climate monitoring stations (see Fig. 2.44).

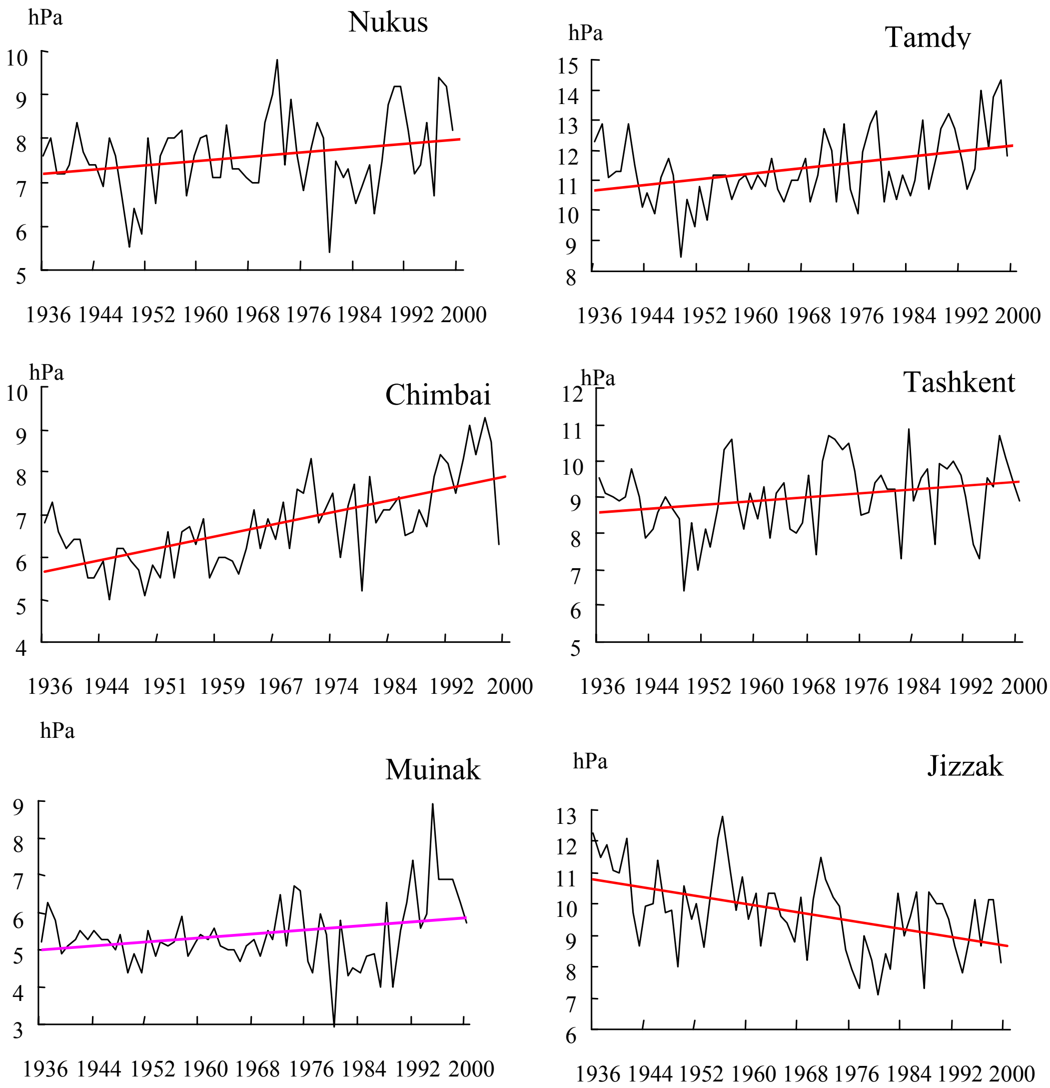
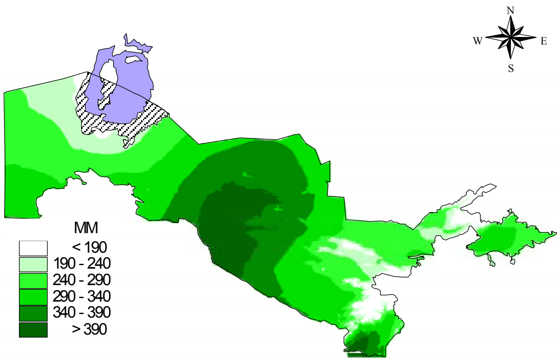


Fig. 2.43. Multi-annual changes in the autumn average humidity deficit registered by monitoring stations in Uzbekistan.

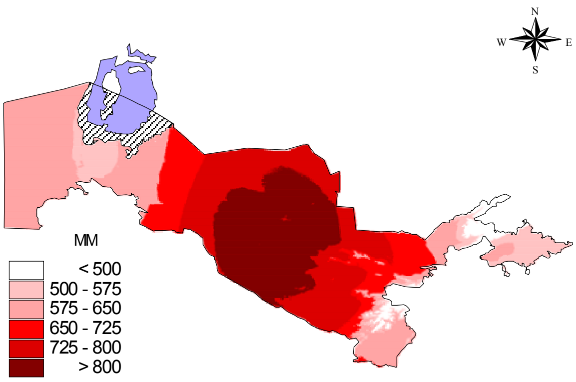
The smallest changes in evaporation in the territory of Uzbekistan have been observed in spring, with the exception of the Aral Sea littoral area where evaporation increases along the shoreline. The biggest changes in evaporation rates have been registered in summer. An increase in evaporation has been observed throughout the plains including the Ferghana Valley as well as the Surkhandarya and Kashkadarya river valleys, with the exception of the Hunger Steppe where evaporation is decreasing under the human-induced impact (irrigation). The area with maximum evaporation rates has expanded. An increase in evaporation has also been detected in autumn (see Fig. 2.44).

An assessment of changes in the Standard Drought Index (*S*) has permitted to compare objectively aridity tendencies in various parts of Uzbekistan and in different seasons.

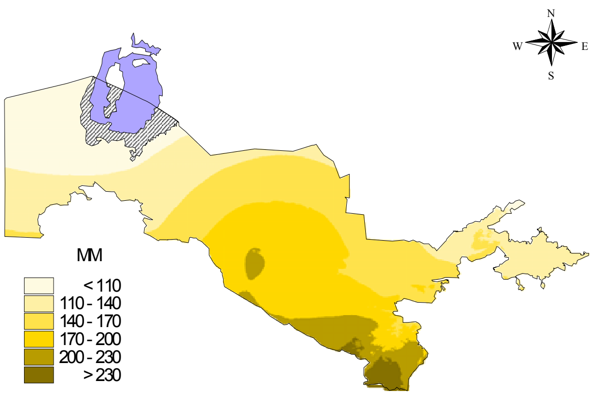
1940-1969 **1970-1999**



Spring (March - May)



Summer (June - August)



Autumn (September - November)

Fig. 2.44. Evaporation rates by seasons of the year in different 30-year periods.

An analysis of index changes has shown that there is a clearly manifested tendency towards increasing aridity in most regions of Uzbekistan, especially in the warm seasons of the year. In the Aral Sea littoral area this tendency is most pronounced due to the Aral Sea regression (see Fig. 2.45).

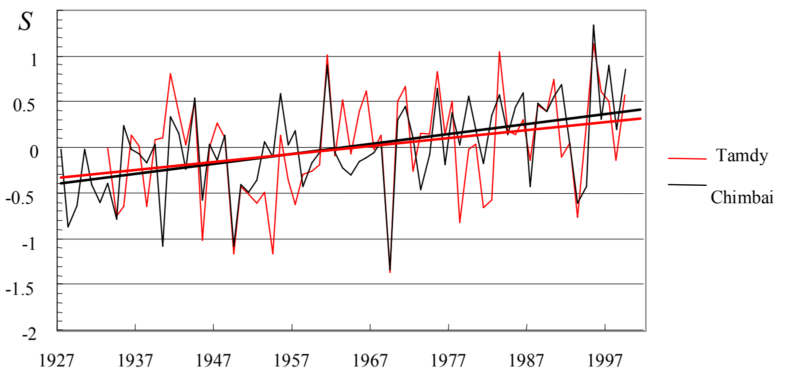


Fig. 2.45. Changes in the annual values of the standard drought index (*S*) registered at the Chimbai station (Aral Sea littoral area) and Tamdy station (central Kyzylkums).

Thus, the following conclusions may be drawn based on the analysis of computed aridity indicators characteristic of the territory of Uzbekistan:

- climate aridity is clearly manifested in the territory of Uzbekistan;
- most of extremely dry years are registered simultaneously throughout the entire territory;
- more obvious tendencies towards climate aridity are traced in summer and autumn, with a high temporal variability;
- the largest share is contributed into the annual trend of aridity increase by the summer season;
- the exposed tendencies may intensify land degradation now in progress in the country.

2.4.3. Changes in the Thermal Stress Level and Human Climatic Comfort

In order to plan work and accomplish practical tasks in the areas of health care, construction, labour and recreation under changing climatic conditions, the extent of climatic comfort changeability and a possible level of thermal stress in the territory of Uzbekistan should be assessed.

Assessment of human comfort based on the temperature-humidity index. The international temperature-humidity index is often used to identify the extent of human comfort. In the present study the index values have been identified for the hot months in the period of 1961 through 2000 based on the daily data of various meteorological stations of Uzbekistan. Strong discomfort is observed in summer months throughout the entire territory of Uzbekistan including the oases.

It should be noted that the temporal series of the temperature-humidity index analysed on the basis of the data supplied by different stations of Uzbekistan have no trends. This testifies to the fact that the given bio-climatic index is not sufficiently susceptible to climate change currently taking place in Uzbekistan.

Assessment of thermal pressure change by the human thermal balance method. The human thermal balance method is more substantiated for the assessment of environmental changes. The human radiation balance is the difference between the radiation (both short- and long-wave) absorbed by the human body and the radiation emanated by it. The amount of heat required for perspiration evaporation (*FLE*) quantifies the thermal pressure on the organism. Under climatic conditions prevailing in most of the territory of Uzbekistan a person loses approximately 4 to 5 litres of water with perspiration.

Of special interest are maximum indicators of thermal pressure on the human organism not protected against sunlight. On the hottest days in May, June and August moisture loss with perspiration exceeds 1,100g/h, and in July this value reaches 1,300 g/h. Such conditions pose a real threat of heat strokes.

In the present study the values of meteorological parameters (such as maximum and minimum air and soil temperature, air humidity, etc.) on the hottest day of the month have been used to compute thermal pressure indicators. Characteristics of the radiation balance have been computed based on the data obtained by actinometric observations. The computations were done for six stations (Urgench, Buzubai, Tashkent, Ferghana, Samarkand and Termez) evenly situated throughout the territory of Uzbekistan.

From May through September the territory of Uzbekistan may be regarded as a zone of extremely high thermal pressure causing a thermal stress. At the Urgench, Tashkent, Ferghana and Termez stations the greater part of the thermal pressure values computed for July and August are classified as ‘excessive thermal pressure’, while at the Buzaubai station thermal pressure in practically all months considerably exceeds the threshold (see Fig. 2.46). Of all the reviewed stations absence of excessive thermal pressure in summer months was observed only at the Samarkand station in the mountain foothills.

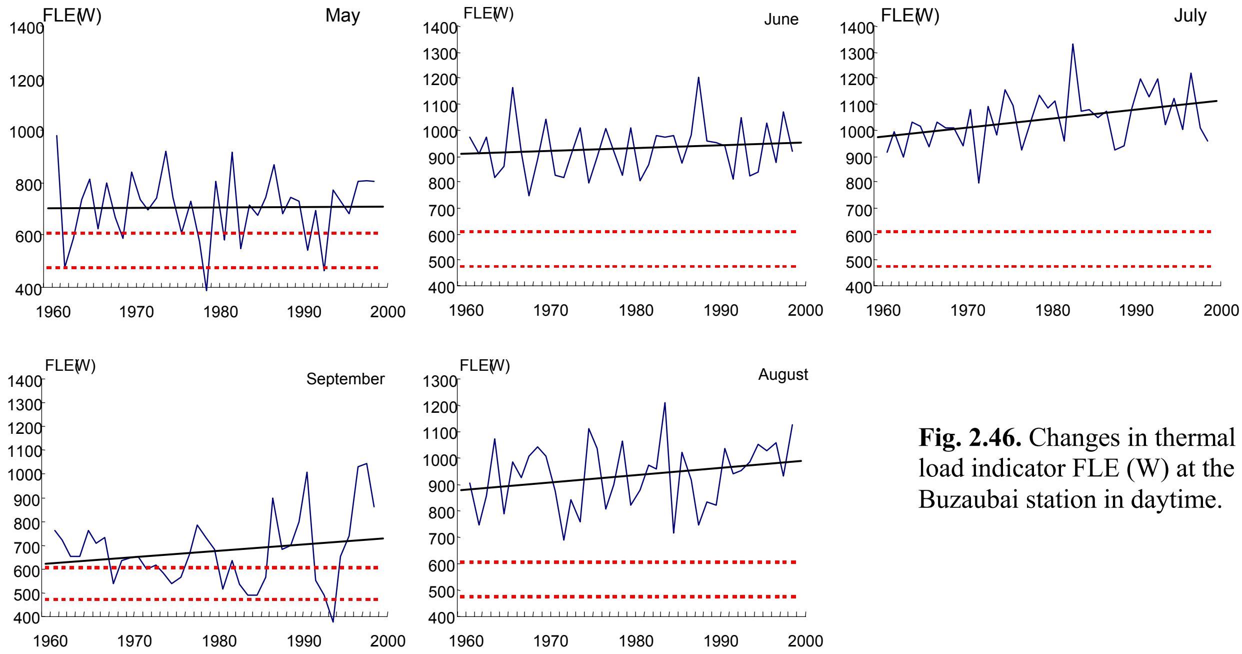


Fig. 2.46. Changes in thermal load indicator FLE (W) at the Buzaubai station in daytime.

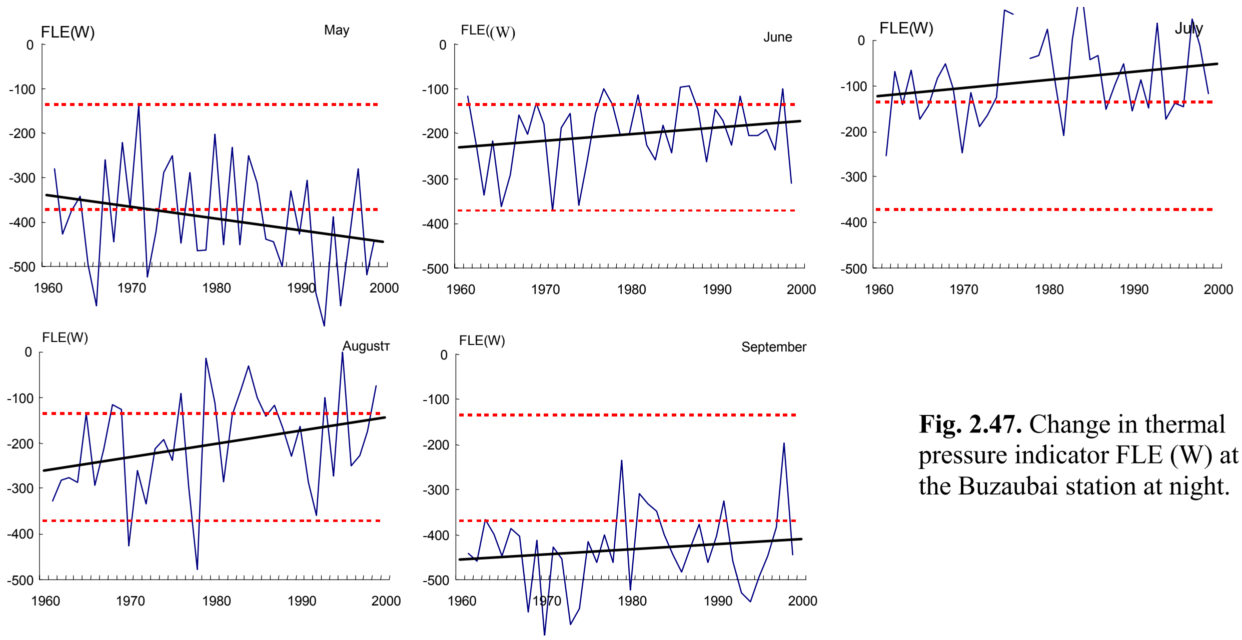


Fig. 2.47. Change in thermal pressure indicator FLE (W) at the Buzaubai station at night.

In some years many stations registered thermal pressure achieving as many as 1,000 W. In such periods there is a high probability of people who stay in the open receiving thermal strokes. Besides that, if such thermal pressure persists for some time it may lead to aggravation of certain diseases, especially among children and elderly people.

An analysis of changes in the computed indicators has shown that a tendency towards increasing thermal pressure was registered in Buzaubai, Termez and Tashkent in July, while in September thermal pressure increased and reached a higher range in Urgench, Samarkand and Ferghana.

In assessing summer bio-thermal conditions in the territory of Uzbekistan of special interest is the night period, when the human organism rests after a high thermal pressure in daytime. An analysis of outputs has shown that up to now the bio-thermal conditions at most reviewed stations are favourable for the night rest. However, substantial tendencies have been detected towards an increase in thermal pressure in summer months. At such stations as Buzaubai and Urgench conditions in the middle of summer became unfavourable for the night rest. Fig. 2.47 illustrates the temporal course of the values of thermal pressure computed on the basis of the meteorological monitoring data at night in Buzaubai.

Thus, climate change that has taken place in Uzbekistan up to the present time has resulted in a tendency towards an increase in the level of thermal pressure both during the day and at night.

Thermal pressure at night has not yet reached the values unfavourable for the night rest, but if the current tendencies persist they will lead to negative consequences in future.

In the event of possible more pronounced climate changes maximum thermal pressure causing thermal stress will increase. To assess changes in the future level of thermal pressure the cited bio-climatic indicators based on the values of meteorological characteristics set in climatic scenarios should be computed on the basis of the present methodology.

2.4.4. Assessing Possible Change in Heating and Air Conditioning Requirements

In view of the climate change a climatic assessment of changes in the duration of heating and air conditioning periods should be undertaken with the aim of a more sustainable use of energy resources of Uzbekistan.

The heating period in Uzbekistan is that when the external air temperature is less than10º C, and for children's pre-school establishments, schools and boarding houses the minimum is less than 12º C. For purposes of climatic assessment the hot period beginning when the temperature exceeds 25º C should be regarded as the air conditioning period, although at some enterprises there exist their own air conditioning norms due to their specific production.

For purposes of municipal planning the dates, when the air temperature steadily exceeds the set ceiling, are computed based on average multi-annual values of monthly air temperatures. The dates of steady transition across such ceilings computed in this way are rather relative and do not reflect the existing climatic tendencies.

For assessing the current changes in the duration of heating and air conditioning periods in the present paper, the dates of steady transition across air temperature ceilings have been computed according to the same methodology based on the 1961-1999 data for the stations in Nukus, Ferghana, Samarkand, Tashkent and Termez.

Assessing changes in the duration of the heating period. In the period under review the dates of steady transition across the ceiling of 10º C in autumn have considerably shifted towards winter, but no substantial changes have been detected in spring. At all the above stations a considerable reduction in the duration of the cold period has been observed. As an example Fig. 2.48 illustrates multi-annual changes in steady dates of 10º C transition in autumn and spring as well as estimated duration of the heating period in Tashkent City.

In the past 30 years the heating period computed on the basis of the t<10º C has reduced by 8 per cent (11 days) in Tashkent, 5 per cent (8 days) in Ferghana, 2 per cent (2 days) in Termez, 4 per cent (4 days) in Nukus, and 9 per cent (13 days) in Samarkand.

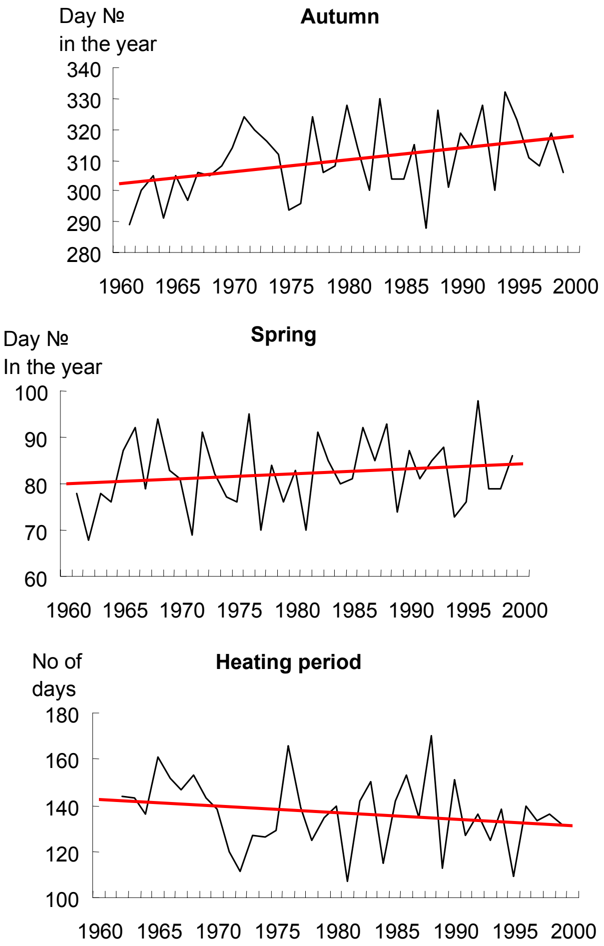


Fig. 2.48. Changes in steady dates of air temperature transition across 10º C and duration of the heating period in Tashkent.

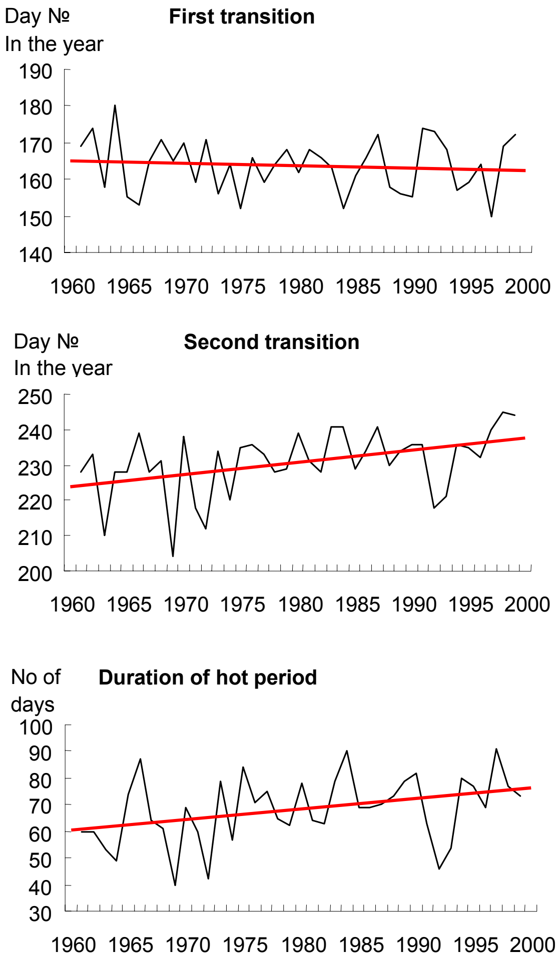


Fig. 2.49. Changes in steady dates of air temperature transition across 25º C and duration of the hot period in Tashkent.

Assessing changes in the duration of the hot period. Computations have shown that in 1961 through 1999 at stations under review the dates of the first steady air temperature transitions across 25º C are slightly shifted towards spring, while the dates of the second steady transitions are considerably shifted towards autumn (see Fig. 2.49).

Over the past 30 years duration of the hot period has increased by 15 per cent (9 days) in Tashkent, 18 per cent (11 days) in Ferghana, 10 per cent (10 days) in Termez, 22 per cent (15 days) in Nukus and almost 40 per cent (19 days) in Samarkand. Such a sharp increase in Samarkand is explained by a short duration of the hot period in 1961-1970 and significant temperature trends in July and August.

Climatic changes in estimated temperatures in the cold period. The estimated temperatures of the cold period include the average temperature of the heating period, the average temperature on five most cold days, the average temperature on the coldest day and ventilation air temperature. The estimated temperatures are used for computing heating systems and identifying fuel consumption norms.

Ventilation temperature used in ventilation design is determined as the average air temperature in the coldest period constituting 15 per cent of the total duration of the heating period. There is a linear dependence between the estimated temperatures and the temperature of the coldest month, and therefore appropriate formulas were used to compute all of the above parameters.

Table 2.13 contains average estimated temperatures of the cold period during 50-year intervals and in the past twenty years for Tashkent City. The estimated temperatures of the past 20 years are considerably higher than that in the earlier periods. This testifies to the fact that if the current tendencies persist, an economic effect may be obtained in the use of energy resources for heating.

Table 2.13. Changes in estimated temperatures of the cold period (º C) in Tashkent

Parameters	Period		
	1901-1950	1951-2000	1981-2000
Average temperature in the coldest month	-0.51	0.89	1.92
Average temperature in the period with the average daily temperature of less than 10º C	3.5	4.6	4.8
Average temperature on the coldest five days	-15.2	-13.5	-12.2
Average air temperature on the coldest day	-17.2	-15.3	-14.0
Ventilation air temperature	-5.3	-3.7	-2.6

Climatic changes of estimated temperatures in the hot period.

In the design of external structures of buildings in southern areas of Uzbekistan, possible overheating of internal premises under the effect of the solar radiation should be taken into consideration. Heat engineering computations in those areas should take into consideration the average air temperature on the hottest day. Table 2.14 contains estimated temperatures of the hot period in 50-year cycles and in the past 20 years in Tashkent. The increase in the average air temperature on the hottest day points to the need of increasing electricity consumption by air conditions.

Table 2.14. Changes in estimated temperatures of the hot period (º C) in Tashkent

Parameters	Period		
	1901-1950	1951-2000	1981-2000
Average air temperature in the hottest month	26.8	27.5	27.9
Average air temperature on the hottest day	33.3	34.0	34.4

Thus, the estimated heating period in the region is reducing while the possible air conditioning period is increasing due to climate change. The average air temperature on the hottest day is rising. Estimated temperatures in both cold and hot periods have a steady tendency to increase.If the current tendencies persist in Uzbekistan it will be possible to reduce energy consumption for heating but increase it for air conditioning.

2.5. Alternative Energy Sources Climatic Capacity

2.5.1. Assessing the Capacity of Wind and Solar Energy Resources in Uzbekistan and Efficiency of Their Use

Unfortunately, the existing network of actinometric and meteorological stations of Uzbekistan does not provide sufficient information for fully assessing the capacity of the wind and solar energy resources at any point of its territory. However, it permits to assess the general availability of such resources in various parts of the country.

Based on an analysis of the territorial distribution of statistical characteristics of wind velocity as well as the shape of the distribution curve at various stations, areas have been identified, within which the wind velocity regime and the wind energy resources may be considered uniform.

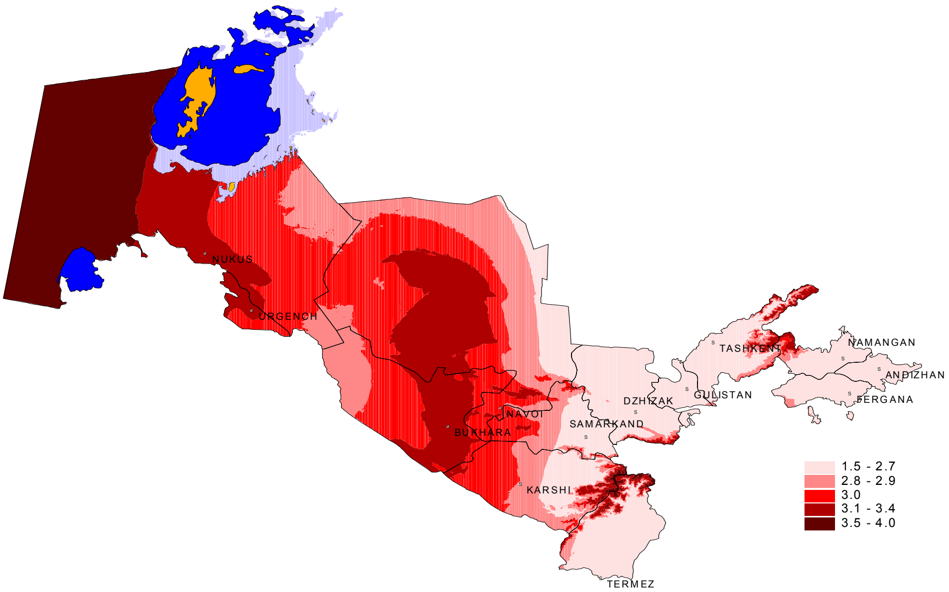


Fig. 2.50. Average annual wind velocity (m/sec).

The North-west of the country and the Aral Sea littoral area, with an average wind velocity constituting 4 to 6 m/sec, are the richest in wind energy resources. In the greater part of the plains the registered average wind velocity is from 3 to 4 m/sec, and the specific capacity of the wind current reaches 150 W/m^2. In the foothills and low mountains the average wind velocity does not exceed 2 – 3 m/sec (see Fig. 2.50), and specific capacity is no more than 100 W/m^2. In some high-mountain areas stronger winds occur as well as in some foothill areas (at the exit from mountain valleys strong winds are observed, but they are rare).

An analysis of the territorial distribution of statistical characteristics of daily amounts of direct (Fig. 2.51) and aggregate (Fig. 2.52) solar radiation permits to identify four areas in Uzbekistan (plains, foothills, mountains and low-mountain depressions) with uniform solar energy resources.

Plains are the richest in solar energy resources. Daily amounts of direct solar radiation vary there from 8-10 MJ/m^2 in winter to 28-30 MJ/m^2 in summer, and daily amounts of aggregate radiation from 7-8 MJ/m^2 to 25-28 MJ/m^2. Duration of sunshine constitutes 10 to 12 hours in summer.

Foothills have somewhat smaller solar energy resources. Daily amounts of direct solar radiation there achieve 25-27 MJ/m^2 in summer, and daily amounts of aggregate radiation reach 24-27 MJ/m^2. Duration of sunshine is 10 to 12 hours, as in the plains.

Mountain territories are not uniform as regards their radiation regime. Intensity of solar radiation in the mountains is very high, but duration of sunshine is 10 to 15 per cent less than in the plains due to greater cloudiness. Given the best conditions of shading and cloudiness, average daily amounts of direct and aggregate solar radiation in the mountains constitute 26-27 MJ/m^2 in summer. Duration of sunshine does not exceed 10 hours.

Low-mountain depressions receive the smallest amounts of solar radiation. Daily amounts of direct solar radiation there do not exceed 25 MJ/m^2 in summer, and daily amounts of aggregate radiation are no more than 25-27 MJ/m^2. Duration of sunshine in the depressions varies between 3.3-4.0 hours in winter and 11.0-11.5 hours in summer.

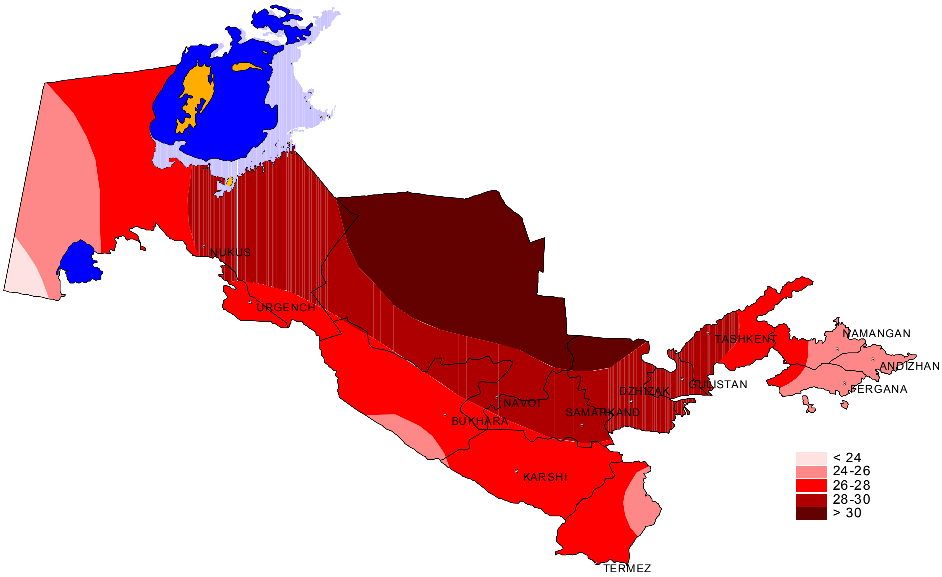


Fig. 2.51. Daily amounts of direct solar radiation (MJ/m^2) in July.

Efficiency of operation of wind and solar energy facilities. **The richest wind energy resources are in the north-west of Uzbekistan (Karakalpakstan and Khorezm). Wind facilities with an initial operating speed of 5 m/sec can function there. On the contrary, solar energy facilities will function less efficiently there due to high cloudiness and a higher concentration of water steam in the atmosphere.**

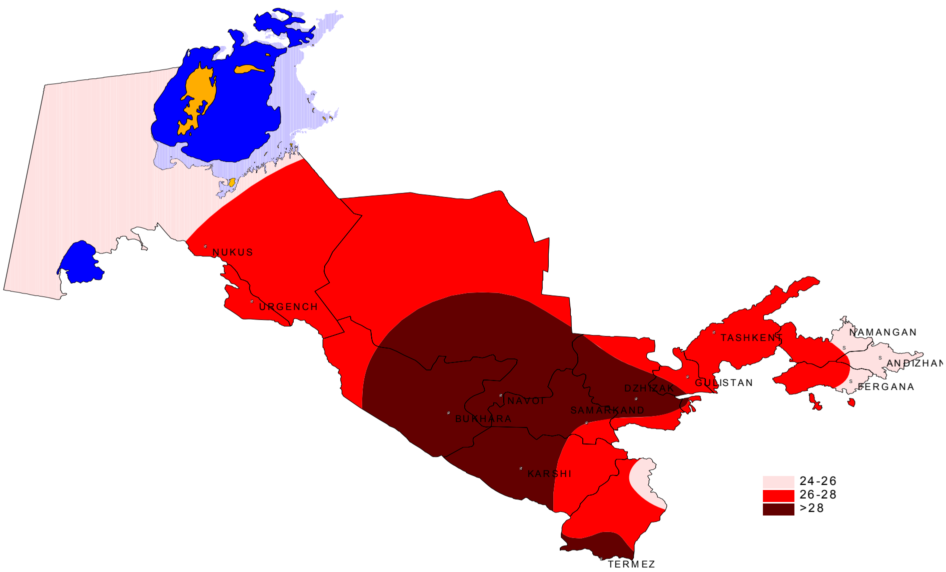


Fig. 2.52. Daily amounts of aggregate solar radiation (MJ/m^2) in July.

The central desert areas are sufficiently rich in both wind and solar energy resources. Wind-driven facilities with an initial speed of up to 3 m/sec can operate with

idling of no more than 50 per cent of operation time. Solar energy facilities can operate with utmost efficiency there. In summer their capacity exceeds 800 MJ/m^2 per month both in facilities using direct solar radiation and in collectors operating on aggregate radiation. In winter they can generate up to 200 MJ/m^2 per month.

Foothills are less rich in both wind and solar energy resources. The average wind velocity is down to 2.0-2.5 m/sec, and therefore wind-driven facilities will operate with long idle periods in most of the foothill territory. Exceptions are some areas situated predominantly at the exit from mountain valleys (near the towns of Yanghiyer and Bekabad and the Charvak water reservoir where the wind regime is characterised, on the one hand, by repeated strong winds, and on the other hand, by long periods of quiet weather. In those areas it would be wise to use wind-driven facilities together with solar ones. Besides that, it will be necessary to ensure a possibility of accumulating energy in periods of strong winds. Solar energy resources in the foothills are also somewhat smaller than in the plains. Nonetheless, its generation reaches 800 MJ/m^2 per month in summer and 150 MJ/m^2 in winter. The foothills are very suitable for using the solar energy.

Mountain areas vary greatly in the amounts of both wind and solar energy. In vast open mountain valleys an average wind velocity is no more than 2.0-2.5 m/sec. Wind-driven facilities will operate with idle time constituting more than 65 per cent of total time. Solar facilities will operate more efficiently than in the plains and foothills. In summer they will generate up to 750 MJ/m^2 per month.

In closed intra-mountain depressions an average wind velocity does not exceed 1.5 m/sec. It is rather inefficient to use wind-driven facilities. As for solar facilities, they will operate with the least efficiency as compared to the rest of the territory of Uzbekistan. In summer months their energy generation does not exceed 650 MJ/m^2. However, solar facilities can serve as a good addition to traditional energy sources.

Strong winds of frequent repetition and an average velocity of over 5m/sec blow at open high-mountain summits and mountain passes. The capacity of the wind energy is rather high. In high-mountain areas intensity of solar radiation is sufficiently high but duration of sunshine is 10 to 15 per cent less than in the plains due to cloudiness. The idle time of solar facilities is longer than in other areas. In summer it may reach 20 to 25 per cent of daytime.

Territorial distribution of wind and solar energy is best represented in schematic maps (Fig. 2.50 – 2.52). Applied wind and solar energy characteristics showing the efficiency of operation of energy facilities in various parts of the country may be mapped in a similar way. At present Glavhydromet of the Republic of Uzbekistan is preparing for publication the “Wind and Solar Energy Cadastre of Uzbekistan’, which will be published early in 2002.

2.5.2. Potential Hydraulic Energy Resources of Uzbekistan

During the assessment of hydraulic energy resources there were 149 hydro-meteorological monitoring posts on rivers, and the total watershed area under observation was 83,369 km^2.

Potential hydraulic energy resources of waterways have been identified by summarising results obtained for separate areas. The metering was carried out on all rivers over 10 km long, with the exception of those drying up and periodically vanishing. The territory under observation was divided into the following areas: a) the Ferghana Valley with an area of 17,600 km^2 within the boundaries of Uzbekistan; b) the Chirchik-Angren basin with an area of 21,100 km^2 within the boundaries of Uzbekistan; c) the South-western area including the valleys of the Zeravshan, Kashkadarya, Sherabaddarya,

Surkhandarya, Sanzar and Zaaminsu rivers, with a total area of 204,400 km^2 within the boundaries of Uzbekistan; d) the lower reaches of the Amudarya River within the boundaries of Khorezm Province and Karakalpakstan, with a total area of 171,700 km^2. Potential hydraulic energy resources of all registered rivers in the years of average water content within the boundaries of Uzbekistan have been assessed at 12.2 million kW and 107 billion kW/h (see Table 2.15).

Table 2.15. **Distribution of areas and potential hydraulic energy resources by provinces of Uzbekistan**

Provinces	Area, 000 km^2	Capacity, 000 kW	Energy, billions kW/h	Energy, % of total	Availability of hydraulic energy resources	
					KW/km^2	000 kW/h per km^2
Andijan	6.2	1971	17.3	16.2	318.0	2800
Bukhara	122.0	648	5.7	5.3	5.3	46
Samarkand	37.7	712	6.2	5.8	18.9	165
Surkhandarya	44.7	2886	25.2	23.6	64.5	564
Tashkent	20.1	4079	35.7	33.4	203.0	1775
Ferghana	11.4	962	8.4	7.8	84.5	736
Khorezm	4.6	200	1.8	1.6	43.5	392
Karakalpakstan	167.0	769	6.7	6.3	4.6	40
Total	**413.7**	**12231**	**107.0**	**100**	**29.6**	**259**

The richest in hydraulic energy resources are Andijan, Tashkent and Ferghana provinces, and the poorest ones are Bukhara Province and Karakalpakstan. The largest hydraulic energy reserves are available in the Ferghana Valley, where 21.7 per cent of all hydraulic energy resources of Uzbekistan and concentrated. Smaller reserves are available in the Karadarya (19.8 per cent), Chirchik (18.6 per cent), Zeravshan (17.4 per cent) and Surkhandarya (9.8 per cent) river basins.

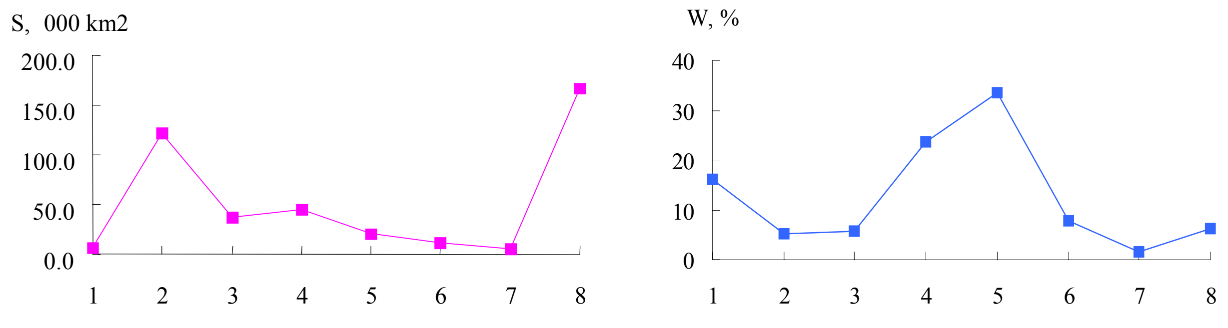


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Fig. 2.53. **Distribution of area (a) and hydraulic energy reserves (b) by provinces of Uzbekistan: 1 – Andijan, 2 – Bukhara, 3 – Samarkand, 4 – Surkhandarya, 5 – Tashkent, 6 – Ferghana, 7 – Khorezm, 8 – Karakalpakstan.**

Hydraulic energy resources have to be specified at present in view of certain registered changes in the hydrological regime using modern technical possibilities.

ANNEX 1

The proposals on transfer technologies in key economy sectors of the Republic of Uzbekistan

RENEWED SOURCES OF ENERGY

Project Category:	**Renewable sources of energy**		**Box № 1**
Project Title	*Construction of a wind-driver power station WPS-6*		
Objective:	Introduction of the modern "know-how" of electrical energy with the use of wind turbines. Preservation of organic fuel and reduction of greenhouse gases emission.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	6,0	
Description:	In Uzbekistan there are territories with prevalence of winds with force more than 6 m/s and 42 % by repeatability in year - line Bekabad-Kokand, where is present a unique opportunity of accommodation of wind units in quantity 10 units by general capacity 6 MWt (WPS-6) with annual production of the electric power 22 million kWt h. The wind energy can be used for irrigation and rise of underground waters.		
Expected Outputs:	The realization of the project will give the significant contribution to development of national power system. The development of wind power will allow to save 7,3 million м^3 of natural gas per one year.		
Required Technologies:	Modules wind power station by capacity of 600 kWt in quantity 10 pieces.		
Volume of Potential Reduction of GHG Emissions:	Development of wind power will allow to keep natural gas for export and to reduce GHG emission for 14, 2 thousand ton of CO_2 per one year.		

OIL AND GAS SUPPLY

Project Category:	**Oil and Gas Supply**		**Box № 2**
Project Title	**Utilization of Accompanying Gas of the Kokdumalak Oil and Condensed Gas Deposit at the Mubarek Oil-and-Gas Processing Plant**		
Objective:	Extraction of valuable components from the accompanying gas at the Kokdumalak deposit using the up-to-date technology. Discontinuance of combustion of the accompanying gas in flares and significant reduction of the actual greenhouse gases emission.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	82	
Description:	The Kokdumalak is the greatest oil-and-condensed-gas deposit of Uzbekistan. Since 1996 they have applied water feeding under water-oil contact to support the stratum pressure; since 1997 – the		

	reverse feeding of dry gas (cycling process) with the same purpose. However, the accompanying gas has not been processed and mostly combusted in flares, which is economically inexpedient and entails considerable greenhouse gases emissions (first of all, the emission of carbon dioxide).
Expected Outputs:	The project implementation will result in rational utilization of the mineral resources. About 109 thousand tons of condensed gas and about 31.6 thousand tons of the light petroleum fraction can be extracted yearly from the natural gas. Dried and purified gas can be used for cycling process. Combustion of gas in flares can be practically discontinued.
Required Technologies:	For the project implementation the up-to-date technologies on deep processing of the accompanying gas with the cryogenic effect are required.
Volume of Potential Reduction of GHG Emissions:	The construction of the unit will make it possible to reduce the CO_2 emission for 34.05 million tons for 30 years of exploitation or in average for 1.135 million tons yearly.

Project Category:	**Oil and Gas Supply**	**Box№3**
Project Title	**Installation pre-cleaning of departing gases by a method SCOT on Mubarek Oil-and-Gas Processing Plant**	
Objective:	Pre-cleaning of departing gases of process of reception of sulfur by a method of Claus from residual sulfur. Reception of additional volume of gas sulfur. Reduction of emission of carbonic gas at the expense of economy of fuel gas in furnaces of burning.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	28,318
Description:	On Mubarek Oil-and-Gas Processing Plant from six blocks of reception of sulfur four blocks have no of the pre-cleaning equipment. Construction of two installations of pre-cleaning of departing gases of process Claus. The installation of a type will raise SCOT a degree of extraction of sulfur on blocks № 1 and №4 first-order factories and will reduce the charge of gas to reburning.	
Expected Outputs:	The realization of the project will promote rational use of mineral resources (additional production of gas sulfur in volume 9,1 thousand tons per one year). Emission of carbonic gas in an atmosphere through flue pipe after burning of sour gases accordingly will decrease.	
Required Technologies:	Technology of pre-cleaning of departing gases of process Claus by a method SCOT	
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce emission CO_2 on 148,0 thousand tons per one year with effect of reduction for 30 years - 4,44 million tons CO_2.	

Project Category:	Oil and gas supply		Box № 4
Project Title	**Installation of system of the automatic control of structure of departing gases and loadings, parity(ratio) hydrogen and oxygen on Mubarek Oil-and-Gas Processing Plant**		
Objective:	Increase of a degree of extraction of gas sulfur from sour gases at the expense of optimization of parameters of technological process. The realization of the project will promote reduction of emission at the expense of reduction of burning of fuel gas.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	0,848	
Description:	The processes of reception of sulfur and pre-cleaning of departing gases pass less effectively at fluctuations of structure and loading of departing gases, parity hydrogen to oxygen. The installation of system of automatic control of the specified parameters line gas analyses equipment of firm a Western Research will allow to increase a degree of extraction of sulfur and to reduce volume of fuel gas to re-burning of sour gas.		
Expected Outputs:	The realization of the project will promote rational use of mineral resources. From natural gas annually will be taken in addition 3,6 thousand tons of sulfur and, accordingly, the emission of harmful substances in an atmosphere, in particular, of carbonic gas will be reduced.		
Required Technologies:	Line gas analyses equipment of firm a Western Research or similar analyzers.		
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce emission CO_2 not less than on 60,0 thousand tons per one year.		

Project Category:	Oil and gas supply		Box № 5
Project Title	**Installation pre-cleaning of departing gases by a method adsorbation on a cold layer of the catalyst on Mubarek Oil-and-Gas Processing Plant**		
Objective:	Pre-cleaning of departing gases from the residual contents of sulfur. The realization of the project will promote reduction of GHG emission in an atmosphere at the expense of reduction of the charge of fuel gas in furnaces reburning of sour gases.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	2,287	
Description:	On Mubarek Oil-and-Gas Processing Plant from six blocks of reception of sulfur four blocks have no pre-cleaning of the equipment. The construction of installation pre-cleaning of departing		

	gases of process Claus by a method adsorbation on a cold layer of the catalyst will allow to raise a degree of extraction of sulfur on blocks №№ 2 and 3 first-order factories and will lower the charge of fuel gas on re-burning of sour gases.
Expected Outputs:	The realization of the project will promote rational use of mineral resources (additional production of gas sulfur in volume 4,8 thousand tons per one year). Emission of carbonic gas in an atmosphere accordingly will decrease.
Required Technologies:	Technology pre-cleaning of departing gases of process Claus by a method adsorbation on a cold layer of the catalyst .
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce emission CO2 on 79,0 thousand tons per one year with effect of reduction for 30 years - 2,37 million tons CO2.

Project Category:	**Oil and gas supply**	**Box №6**
Project Title	*Gas fractional installation on Fergana Oil-and-Gas Processing Plant*	
Objective:	Increase of depth of processing of CH of passing gases. Reduction of burning of gases on torch installations.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	76,782
Description:	On Fergana Oil-and-Gas Processing Plant in the technological circuit of processing at work of installations ABT (1, 2, 3, 4), L-35-11/300, LCH-35-11/600 there is no gas fractional installation division easy CH gases of raw material, that creates a problem on use of "greasy" gas and "heads" of stabilization of the above-stated installations. The basic part CH of gases is burnt in furnaces as technological fuel, the surplus is burnt on a torch.	
Expected Outputs:	The realization of the project will promote rational use of resources CH of gases. Fraction of CH gases will allow annually to receive propan-butan fraction in quantity 106.05 thousand tons and fraction C5 additional in quantity 28.3 thousand tons. Also will result in sharp reduction of volumes of burning of gas on torches.	
Required Technologies:	Modern technological processes of division of mixes easy limiting CH gases with use of cryogenic effect.	
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce issue CO2 not less, than on 0.208 million tons/year or 6,240 million tons for 30 years	

Project Category:	Oil and Gas		Box № 7
Project Title	**Reconstruction of Flare System of the Main Units of the Oil and Gas Enterprise "Shurtanneftegaz"**		
Objective:	Utilization of exhausted flare gases and corresponding reduction of volumes of gases combusted in flares. Reduction of greenhouse gases emissions.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	59,534	
Description:	The existing flare system where all the flare gases are combusted for the purposes of technical safety and pressure decrease, underwent to wear and tear and is obsolete. The proposed reconstruction of the flare system will make it possible to collect the continually combusted low-sulphurous gases in gas-holders, revert them in the system by compressing and reduce the carbon dioxide emission.		
Expected Outputs:	The project implementation will facilitate the utilization of the flare gases in volumes of 200 million cubic meters per year. Accordingly, the volumes of gas combusted in flares and greenhouse gases emissions will reduce.		
Required Technologies:	Up-to-date economical flare systems		
Volume of Potential Reduction of GHG Emissions:	The reconstruction will allow reduce the CO_2 emission for 0.474 million tons per year; the 20-year reducing effect equals to 9.48 million tons of CO_2.		

Project Category:	Oil and gas supply		Box № 8
Project Title	**The second step of installation of reception of sulfur by a method of direct oxidation on Mubarek Oil-and-Gas Processing Plant**		
Objective:	Increase of a degree of conversion hydrogen in sulfur on installation of direct oxidation and reduction of GHG emission in an atmosphere at the expense of economy of fuel gas in furnaces re-burning of sour gases.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	0,87	
Description:	For increase of a degree of conversion hydrogen in sulfur at processing all of more increased volumes of gases and for optimization of technological process of reception of sulfur by a		

	method of direct oxidation the construction of the second step of installation of direct oxidation is necessary, that will entail increase of a degree of conversion of sulfur, reduction of the charge of fuel gas.
Expected Outputs:	The realization of the project will promote rational use of mineral resources (additional development of sulfur in volume 3,2 thousand ton per one year). The emission in an atmosphere of GHG will accordingly be reduced.
Required Technologies:	2 step technologies of reception of sulfur by a method of direct oxidation at processing of gases.
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce emission CO2 on 26,0 thousand tons per one year with effect of reduction for 20 years on 0.52 million tons CO_2.

Project Category:	**Oil and gas supply**		**Box №9**
Project Title	*Reconstruction of torch system on Mubarek Oil-and-Gas Processing Plant*		
Objective:	Recycling of torch dumps of CH gases appropriate reduction of their burning on torches and reduction of GHG emission.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	60,0	
Description:	In existing to torch system there is a process of the tax, burning and dispersion sour and gas wastes from technological installations with the purpose of neutralization these wastes during a conclusion of installations to a mode, at infringements of a technological mode, at clearing devices and pipelines for repair work. Essence of reconstruction - tax constantly burning down CH gas wastes in gasholders and return them in system by compremition.		
Expected Outputs:	The realization of reconstruction on the basis of modern technologies will allow utilizate up to 250 million м3 of gas, accordingly to reduce volume of burning on torches and to lower GHG emission.		
Required Technologies:	Modern western technologies on recycling of torch dumps on objects gas processing.		
Volume of Potential Reduction of GHG Emissions:	Realization of designing and construction of the project will allow to reduce annual issue CO2 in volume not less than 0,497 million tons, for 20 years - 9.94 million tons.		

Project Category:	Oil and gas supply		Box№ 10
Project Title	*Reconstruction of compressor station KS-0 in Mubarek city*		
Objective:	Replacement out-of-date morally and physically of gas turbine compressors such as GPA-C-6,3/56-1,45 on a modern type with economy of fuel gas and reduction of GHG emission.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	63,81	
Description:	Established in 1981 on KS-0 units GPA-C-6,3/56-1,45 now already are removed from manufacture. Instead of 9th established units is offered to establish 4 new units GPA-C1-16CK/56-1,44 (3 workers and 1 reserve), having more high efficiency and capacity, higher EFFICIENCY and low specific emissions NOx and CO.		
Expected Outputs:	As a result of reconstruction same volume of gas after processing on Mubarek Oil-and-Gas Processing Plant will be transfer with the smaller charge of fuel gas on gas turbines and with smaller GHG emission .		
Required Technologies:	Swapping of gas on main gas pipelines with use of the modern compressor GPA-C1-16CK/56-1,44 of manufacture of Ukraine.		
Volume of Potential Reduction of GHG Emissions:	The realization of the project will result in reduction of CO_2 emission annually on 111,0 thousand tons, for 20 years - on 2,22 million tons.		

Project Category:	Oil and gas supply		Box № 11
Project Title	**Reconstruction of thermal boiler-houses №1 and №2 on Mubarek Oil-and-Gas Processing Plant**		
Objective:	Perfection of gas devices and thermal networks of boiler-houses with the purpose of economy of fuel gas and respective reduction of GHG emission.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	2,5	
Description:	The boiler-house №1 works from the date of the basis Mubarek Oil-and-Gas Processing Plant , i.e. since 1971, boiler-house №2 - since 1980. Now it is marked in a various degree physical both obsolescence of the equipment and system of thermal networks. The essential need for realization of reconstruction with installation of the modernized torches for gas, replacement of auxiliaries and structures, system chemical water cleaning, fallow wires and pipelines of return of a condensate has come to light.		
Expected Outputs:	As a result of reconstruction of boiler-houses and replacement of units economic the gas devices and reconstruction of thermal networks will achieve economy of fuel gas up to 10 % from consumed now. Accordingly, the GHG emission will be reduced.		

Required Technologies:	The gas device of a modern type ensuring economy of fuel gas.
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow at the expense of economy of fuel gas to reduce CO2 emission on 52,6 thousand tons, for 20 years - on 1,052 million tons

Project Category:	**Oil and Gas supply**	**Box № 12**
Project Title	**Reconstruction of Compressing Stations of the Main Units at the Gazli Deposit**	
Objective:	Increase of the active volume of underground gas storage	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	100,0
Description:	The existing compressing stations of the main units of the Gazli deposit consist of 39 Gas-Pumping Aggregates (GPA) with the total power of 162 MWt. The introduction of 5 GPA with the total power of 102 MWt.	
Expected Outputs:	Increased volume of gas pumping and withdrawal up to 3 billions cubic meters per year. Reduced fuel gas consumption for 56 billions cubic meters. Reduced operation and maintenance costs and number of personnel.	
Required Technologies:	Gas Pumping Aggregates of increased efficiency	
Volume of Potential Reduction of GHG Emissions:	The project implementation will make it possible to reduce the emission of CO_2 for 154 thousand tons, NOx for 521 tons, CH_4 for 3 million cubic meters (or 45.36 thousand tons of CO_2 equivalent) yearly.	

Project Category:	**Oil and gas supply**	**Box№13**
Project Title	**Reduction of outflow of gas at compressor stations CS-2 and CS-3 in Company "Uztransgas"**	
Objective:	Reduction of methane emission from outflow at transportation of natural gas.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	3,8
Description:	By virtue of a deterioration of the equipment of compressor stations the annual outflow of methane make more than 80 millions cubic meters.	
Expected Outputs:	Reduction of losses of gas on 43,6 million cubic meters	
Required Technologies:	The modern constipating fixture and compressing materials	
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce annually CH4 emission on 43,6 millions cubic meters or 641 thousand tons in a CO2-equivalent.	

Project Category:	Oil and gas supply		Box № 14
Project Title	**Reduction of outflow of gas on a main gas pipeline in Company "Uztransgas"**		
Objective:	Reduction of methane emission from outflow at transportation of natural gas.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	64,0	
Description:	By virtue of a deterioration of the equipment of compressor stations the annual outflow of methane at transportation of gas make more than 30 million cubic meters.		
Expected Outputs:	Reduction of losses of gas at transportation on 10,0 million cubic meters.		
Required Technologies:	The modern constipating fixture and compressing materials.		
Volume of Potential Reduction of GHG Emissions:	The realization of the project will allow to reduce annually CH_4 emission on 10 million cubic meter or 147 thousand tons in a CO_2-equivalent.		

ELECTRIC POWER INDUSTRY

Project Category:	Electric Power Engineering		Box № 15
Project Title	**Reconstruction of electric unit on " Tashkent Hydro Plant"**		
Objective:	Introduction of the up-to-date technology for electricity and heat co-generation based on steam-gas turbines. Increase of efficient use of organic fuel and reduction of greenhouse gases emissions.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	221,0	
Description:	The project proposes to replace two steam-gas turbines with capacity of 300 MWt of electric power and 380 GCal/h of heat power for 1 steam-gas turbine.		
Expected Outputs:	The implemented project will considerable contribute in development of the national power system. Installation of two steam-gas turbines on the Tashkent Hydro Plant will allow to save up 434 thousand tons of organic fuel per year due to reduced specific fuel expense per a unit of produced power, and to reduce the power shortage in the region.		
Required Technologies:	1 steam-gas turbine with capacity of 370 MWt		
Volume of Potential Reduction of GHG Emissions:	Installation of two steam-gas turbines will make it possible to reduce consumption of organic fuel and the CO_2 emission for 710 thousand tons per year.		

Project Category:	Electric Power Engineering	Box № 16
Project Title	**Reconstruction of electric unit on " Navoi Hydro Plant"**	
Objective:	Introduction of the up-to-date technology for electricity and heat co-generation based on steam-gas turbines . Increase of efficient use of organic fuel and reduction of greenhouse gases emissions.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	232,0
Description:	The project proposes to replace two steam-gas turbines with capacity of 50 MWt of electric power and 402 GCal/h of heat power for 1 steam-gas turbine.	
Expected Outputs:	The implemented project will considerable contribute in development of the national power system. Installation of two steam-gas turbines on the Navoi Hydro Plant will allow to save up 458 thousand tons of organic fuel per year due to reduced specific fuel expense per a unit of produced power, and to reduce the power shortage in the region.	
Required Technologies:	1 steam-gas turbine with capacity of 350 MWt	
Volume of Potential Reduction of GHG emissions:	Installation of two steam-gas turbines will make it possible to reduce consumption of organic fuel and the CO_2 emission for 751 thousand tons per year.	

Category of Project:	Electric Power Engineering	Box № 17
Project Title	**Installation of Gas Turbine Unit (GTU) with Utilizing Boiler at the Tashkent Heat Power Plant (HPP)**	
Objective:	Introduction of up-to-date technology for electricity and heat co-generation based on gas turbines with utilizing boilers. Increase of efficiency of consumed organic fuel and reduction of greenhouse gases emissions.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	22,0
Description:	The project proposes to install one gas turbine with utilizing boiler with productive capacity of 64 MWt of electricity and 71.3 Gcal/hour of heat. The consumed fuel will fall down to 151.4 gram/KWt/hour against the existing amount of 380 gram/KWt/hour	
Expected Outputs:	The implemented project will significantly contribute in development of the national power system. Installation of the GTU at the Tashkent HPP will save up 106 tons of organic fuel per year due to reduced specific fuel expense per a unit of produced power.	
Required Technologies:	1 gas turbine with utilizing boiler with capacity of 64 MWt	
Volume of Potential Reduction of GHG Emissions:	Installation of GTU with utilizing boiler will make it possible to reduce consumption of organic fuel and the CO_2 emission for 175 thousand tons per year.	

Project Category:	**Electric Power Engineering**	**Box № 18**
Project Title	**Reconstruction of Mubarek Heat Power Plant (HPP)**	
Objective:	Introduction of the up-to-date technology for electricity and heat co-generation based on gas turbines with utilizing boilers. Increase of efficient use of organic fuel and reduction of greenhouse gases emissions.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	98,9
Description:	The project proposes to instalation on Mubarek HPP two gas turbines with utilizing boiler with capacity of 106,3 MWt of electric power and 260 GCal/h of heat power, which will reduce the consumed fuel down to 158,1 gram/KWt/h against the existing 380 gram/KWt/h.	
Expected Outputs:	The implemented project will considerable contribute in development of the national power system. Installation of the Gas Turbine Unit (GTU) at the Heat Power Plant will allow to save up 220 thousand tons of organic fuel per year due to reduced specific fuel expense per a unit of produced power, and to reduce the power shortage in the region.	
Required Technologies:	Two gas turbine with utilizing boiler with capacity of 53,15 MWt	
Volume of Potential Reduction of GHG Emissions:	Installation of GTU with utilizing boiler will make it possible to reduce consumption of organic fuel and the CO_2 emission for 362 thousand tons per year.	

Project Category:	**Electric Power Engineering**	**Box № 19**
Project Title	**Reconstruction of Joint-Stock Venture "Bukharaenergomarkaz"**	
Objective:	Introduction of the up-to-date technology for electricity and heat co-generation based on gas turbines with utilizing boilers. Increase of efficient use of organic fuel and reduction of greenhouse gases emissions.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	40,0
Description:	The project proposes to replace 4 KVGM-50 boilers to 1 gas turbine with utilizing boiler with capacity of 62 MWt of electric power and 81 GCal/h of heat power, which will reduce the consumed fuel down to 172 gram/KWt/h against the existing 380 gram/KWt/h.	
Expected Outputs:	The implemented project will considerable contribute in development of the national power system. Installation of the Gas Turbine Unit (GTU) at the Heat Power Plant will allow to save up 96 thousand tons of organic fuel per year due to reduced specific fuel expense per a unit of produced power, and to reduce the power shortage in the region.	
Required Technologies:	1 gas turbine with utilizing boiler with capacity of 62 MWt	
Volume of Potential Reduction of GHG Emissions:	Installation of GTU with utilizing boiler will make it possible to reduce consumption of organic fuel and the CO_2 emission for 162 thousand tons per year.	

Project Category:	Electric Power Engineering	Box№ 20
Project Title	*Hydroelectric power station on the river Pskem by capacity 404 MWt*	
Objective:	Introduction of the modern renewed "know-how" of electrical energy. The seasonal regulation of a drain of the river Pskem	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	420,0
Description:	The structure of HYDROELECTRIC POWER STATION on the river Pskem by electrical capacity 404 MWt is offered.	
Expected Outputs:	The realization of the project will give the significant contribution to development of national power system. The introduction Pskem HYDROELECTRIC POWER STATION will allow to keep 360 thousand tons of organic fuel per one year at the expense of decrease reduction of the specific charges of fuel on unit of the made electric power, to improve providing of water of region and to create additional irrigation lands.	
Required Technologies:	Four hydro installations by general capacity 404 MWt.	
Volume of Potential Reduction of GHG Emissions:	Introduction of hydroelectric power station will allow to reduce consumption of organic fuel and to reduce CO2 emission for 1000 thousand tons per one year.	

Project Category:	Electric Power Engineering	Box № 21
Project Title	**Introduction of energy-saving complex on Talimarjan hydroelectric power station**	
Objective:	Introduction of modern technology of the savings of electrical energy by recycling superfluous pressure of natural gas on gas distribution unit.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Energy	2,5
Description:	The installation two units of detander-generating-aggregate DGA-5000 by electrical capacity on 5 MWt on gas distribution unit of Talimarjan hydroelectric power station is offered.	
Expected Outputs:	The realization of the project will give the contribution to development of national power system. The introduction two DGA-5000 will allow to keep 7,65 thousand tons of organic fuel per one year at the expense of recycling superfluous pressure of natural gas on gas distribution unit without use of fuel.	
Required Technologies:	Two detander-generating-aggregates by capacity on 5 MWt.	
Volume of Potential Reduction of GHG Emissions:	Introduction DGA will allow to reduce consumption of organic fuel and to reduce CO2 emission for 12,6 thousand tons per one year.	

MUNICIPAL HEATING SUPPLY

Project Category:	District Heating		Box № 22
Project Title	**Utilization of Domestic Waste as the Low-Calorie Fuel (Incinerating Plant in Samarkand City)**		
Objective:	Introduction of new technology of utilization of domestic waste as the low-calorie fuel for electricity and heat production. Liquidation of methane emitted from the solid waste disposal sites. Saving of organic fuel and reduction of greenhouse gases emissions.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Municipal Heat Supply	45	
Description:	In Uzbekistan about 6.5 millions ton of solid domestic waste are yearly collected and stored without preliminary processing and separation within fractions and useful components. As a result of biological processes of decomposing the dumps emit the products of decay in the atmosphere. The West-European countries' practice shows that the waste can be used as the low-calorie fuel. The project proposes to built an incinerating plant with the capacity up to 400 thousand tons of waste per year aimed at production of electricity and heat. The effectiveness equals to 90 %; the produced heat and electricity will be consumed by the inhabitants.		
Expected Outputs:	93 millions cubic meters of natural gas will be saved up, the CO_2 emission will be reduced, the lands under dumps (6.0 hectare per year) will be disengaged, the sanitation and environment state of the region will be enhanced.		
Required Technologies:	Technology to utilize the waste and accompanying methane for 400 thousand tons yearly; Line for receiving and collection of waste; Line for low-temperature incineration; Electricity generators based on over-heated steam; Line for processing of hot water for district heating; Line for purification and cooling the gases; Treatment units; Controlling system of the stages of technological cycle; Know-how and experience.		
Volume of Potential Reduction of GHG Emissions:	The waste utilization will make it possible to save up natural gas for export purposes and reduce the methane for 128,1 thousand tons of CO_2 emission yearly.		

Project Category:	District Heating		Box № 23
Project Title	**Technology of Electric and Heat Generation on the Base of a Biogas from the Surplus Active Sludge at the Water Treatment Plant of Tashkent City**		
Objective:	Introduction of up-to-date technology to produce a biogas (methane) from surplus active sludge to be used for technological power supply of canalization and water treatment plants of large cities. Liquidation of methane emission from sludge platforms. Saving up of the organic fuel and reduction of greenhouse gases emissions.		
Country	**Sector**	**Budget, million**	

		US $
Uzbekistan	Municipal Heat Supply	8,0
Description:	Over 1 million tons of surplus sludge is yearly formed at the canalization and water treatment plants of Uzbekistan, which requires substantial efforts for its disinfecting from different bacteria and intestinal worms. In West-European countries there are technologies of high-temperature fermenting the waste included organic components, for generation of methane. The technologies provides processing of active sludge in special methane tanks with permanent temperature of 58 ^{0}C. The process of biological disinfecting lasts 72 hours; the process results in forming a compound of inflammable gases (60 % of which is methane) and an organic fertilizer. The applied technologies will make it possible to fully provide the canalization and water treatment plants with electric and heat power, disinfect the sludge from microorganisms, while the obtained product can be used as a highly efficient biological fertilizer.	
Expected Outputs:	Saved up 29.8 millions cubic meters of natural gas, reduced emission of greenhouse gases in the amount of 19 thousand tons of CO_2.	
Required Technologies:	Technology of generating biogas in methane tanks due to high-temperature rapid fermentation of organic component of the active sludge resulted in evolving methane; Gas generators of electricity and heat power and lines for heating water for district heating; Lines for purification and cooling of the released gases; Treatment units; Controlling system of the stages of technological cycle; Know-how and experience.	
Volume of Potential Reduction of GHG Emissions:	The waste utilization will allow to reduce the methane emission in the amount of 19 thousand tons of CO_2 emissions per year.	

INDUSTRIAL PROCESSES

Project Category:	**Chemical industry**	**Box № 24**
Project Title	**Reconstruction of manufacture of carbamide on Chirchik plant "Electrochimprom".**	
Objective:	Reconstruction of manufacture of carbamide with the purpose of increase of productivity and technological safety, of energy saving and CO2 emission, and also reduction of technological emissions.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Industrial processes	59,66
Description:	Synthesis of carbamide is carried out from liquid ammonia and carbonic gas at temperature 183 C and pressure 134-144 atmospheres. The established capacity of manufacture 270 thousand tons/year. The accepted technology is obsolete, has a some lacks, including the underestimated ecological requirements, and is subject to reconstruction.	
Expected Outputs:	The stable, safe and facilitated operation of existing installation on manufacture of carbamide with increase of productivity up to 330 tons per one year and with reduction of emissions of CO2 and	

	technological dust.
Required Technologies:	The new technological circuit of manufacture of carbamide includes separate technological lines of synthesis, of distillation, of compressing, of granulation in granulation tower (on existing installation), extraction, clearing of a technological condensation, and also "know-how" on compression of ammonia; compression of CO_2; to synthesis of carbamide; recycling; streaming; to introduction carbamide-formaldegide in melting of pitch; granulation; absorption, desorption, hydrolysis; special water circulation to a cycle.
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to lower emissions CO_2 up to 127 thousand tons per one year.

Project Category:	**Chemical industry**	**Box №25**
Project Title	**Construction of the new unit of ammonia on Chirchik plant "Electrochimprom" on technology of firm "Haldor-Topse".**	
Objective:	Introduction of modern energy-saving "know-how" of ammonia with the purpose of increase of productivity and technological safety, energy saving and CO_2 emission, reduction of technological emissions.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Industrial processes	263,56
Description:	By the project is provided construction of the new unit of ammonia by capacity of 1000 tons per day under the technological circuit of the company " Haldor-Topse" instead of the old unit maintained with 1940. The unit of manufacture of ammonia under the circuit of the company " Haldor-Topse" does not consume the electric power from the party, since in its structure is present turbine generator, developing it for own needs, and the surpluses of the electric power can be used in other manufactures. With commissioning of the new unit of ammonia the consumption of natural gas, electric power, becoming cold water and other materials, power resources and components is reduced. The commissioning of the modernized manufacture with a high degree of automation and use of the modern equipment will allow to liquidate out-of-date manufacture of ammonia, the sources of which emissions bring in the basic contribution to pollution of atmospheric air, selective zone on ammonia and CO_2.	
Expected Outputs:	Significant reduction of concentration of emissions of ammonia (on 5,8- 6,8 up possible concentration) and CO_2 (on 1,3-1,5 up possible concentration). Reduction water use (on 61 %) and volume of waste water, which throw out in a superficial reservoir (on 25,5 %). Increase of productivity up to 1000 tons of ammonia per day and with reduction of CO_2 emissions.	
Required Technologies:	The technological circuit of manufacture of ammonia of the company " Haldor-Topse".	
Volume of Potential	Realization of the project will allow to lower emissions of CO_2	

Reduction of GHG Emissions:	on 205 thousand tons per one year.

Project Category:	**Chemical industry**		**Box № 26**
Project Title	**Reconstruction of carbamide manufacture on Fergana plant "Azot " "(Nitrogen)"**		
Objective:	Reconstruction of carbamide manufacture with the purpose of increase of productivity, technological safety and decrease of CO_2 emission and technological emissions.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Industrial processes	71	
Description:	Synthesis of carbamide is carried out from liquid ammonia and carbonic gas at temperature 183 C and pressure 134-144 atmospheres. The established capacity of manufacture 231 thousand tons/year. The accepted technology is obsolete, has a some lacks, including the underestimated ecological requirements, and is subject to reconstruction.		
Expected Outputs:	The stable, safe and facilitated operation of existing installation on manufacture of carbamide with increase of productivity up to 264 tons per one year and with reduction of CO_2 emissions and technological dust.		
Required Technologies:	The new technological circuit of manufacture of carbamide of firm "Stamicarbone" (Holland) includes separate technological lines on of synthesis, distillation, of compressing, of granulation in granulation tower (on existing installation), extraction, clearing of a technological condensate, and also "know-how" on compression of ammonia; compression of CO_2; to synthesis of carbamide; recycling; streaming; to introduction carbamide-formaldegide in melting of pitch; granulation; absorption, desorption, hydrolysis; special water circulation to a cycle.		
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to lower emissions CO_2 on 138 thousand tons per one year.		

Project Category:	**Chemical industry**		**Box № 27**
Project Title	**Reconstruction of the large-weighty of the unit of ammonia on Fergana plant "Nitrogen"(Azot).**		
Objective:	Introduction of the modern energy saving "know-how"technology of ammonia production with the purpose of increase of productivity and technological safety, save energy and CO_2 emission, reduction of technological emissions.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Industrial processes	25,0	
Description:	By initial raw material for manufacture of ammonia is natural gas acting from a network under pressure 1,0-1,2 MPa with temperature -40-35C. The natural gas given from a network, in the unit is divided into two flows: one - for the technological purposes, another - on burning as fuel. The fuel gas through the		

	decontaminator is directed on burning. The project provides reconstruction of the unit of ammonia and increase of its productivity with 1360 up to 1435 tons per day. The modernization of installation includes decrease of general difference of pressure of installation by updating of reforming (primary and secondary) and methanetor and operation of a new basket of a column of synthesis at low pressure and lowered difference of pressure; optimization of operational conditions with application of the new catalyst basically reactor and downturn of the relation pair - gas; optimization of work on installation of monoethanolamine clearing with improvement of the relation pair - gas; maximal use low of potential heat and regeneration of a technological condensate.
Expected Outputs:	Decrease the concentration of ammonia and CO2 emissions. Increase of productivity up to 1435 tons of ammonia per day and with reduction of CO2 emissions.
Required Technologies:	The process equipment is accepted domestic and, partially, import. The turbine to the compressor of natural gas, block steam of reforming with system pair production will be put from Czechoslovakia, from Japan the compressor of nitrogen-hydrogen mix ROU 100/40 will be put. A part of equipment, fixture and pipelines will be put by the French firm "Mazonaman". All other equipment is domestic.
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to lower emissions CO2 on 357 thousand tons per one year.

Project Category:	**Chemical industry**	**Box № 28**
Project Title	**Reconstruction of the large-weighty the unit of ammonia on Chirchik plant "Electrochimprom"**	
Objective:	Introduction of the modern energy saving "know-how" technology of ammonia with the purpose of increase of productivity and technological safety, save energy and CO2 emission, reduction of technological emissions.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Industrial processes	25,0
Description:	By initial raw material for manufacture of ammonia is natural gas acting from a network under pressure 1,0-1,2 MPa with temperature -40-35C. The natural gas given from a network, in the unit is divided into two flows: one - for the technological purposes, another - on burning as fuel. The fuel gas through the decontaminator is directed on burning. The project provides reconstruction of the unit of ammonia and increase of its productivity with 1360 up to 1435 tons per day. The modernization of installation includes decrease of general difference of pressure of installation by updating of reforming (primary and secondary) and methanetor and operation of a new	

	basket of a column of synthesis at low pressure and lowered difference of pressure; optimization of operational conditions with application of the new catalyst basically reactor and downturn of the relation pair - gas; optimization of work of installation of the monoethanolamine clearing with improvement of the relation pair - gas; Maximal use low of potential heat and regeneration of a technological condensate.
Expected Outputs:	Decrease of concentration of emissions of ammonia and CO2. Increase of productivity up to 1435 tons of ammonia per day and with reduction of CO2 emissions.
Required Technologies:	The process equipment is accepted domestic and, partially, import. The turbine to the compressor of natural gas, block steam reforming with system pair production will be put from Czechoslovakia, from Japan the compressor of nitrogen-hydrogen mix ROU 100/40 will be put. A part of equipment, fixture and pipelines will be put by the French firm "Mazonaman". All other equipment is domestic.
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to lower emissions CO2 on 357 thousand tons per one year.

Project Category:	**Electric Power Engineering**		**Box № 29**
Project Title	**Construction of energy unit on Navoi plant "Navoiazot"**		
Objective:	Introduction of the modern "know-how" technology on production of electrical and thermal energy with the use of pair-gas turbines for industrial requirements of Navoi plant "Navoiazot". Increasing of efficiency of use of organic fuel and reduction of GHG emission.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Energy	136,6	
Description:	As a duplicating source of power supply plant "Navoiazot" propose the construction two pairturbine energy blocks is offered complete with boiler -utilizators by capacity 232,8 MWt and pair production 400tons/hour.		
Expected Outputs:	Construction own energy unit and the creation of the flexible circuit of power supply plant "Navoiazot" stabilizes work and will lower losses of release of commodity production at switching-off of energy system. Will decrease on 148 thousand tons of organic fuel. Expenses of fuel for manufacture of the electric power. Loading of Navoi Hydro Plant will decrease.		
Required Technologies:	The firm " Clekner INA " provides delivery of two gas turbine installations, complete with boiler - utilizators and all necessary equipment.		
Volume of Potential Reduction of GHG Emissions:	Introduction of pair-gas installation will allow to reduce consumption of organic fuel and to reduce CO2 emission on 343 thousand tons per one year.		

Project Category:	Chemical industry		Box № 30
Project Title	**Construction of new manufacture of carbamide on Navoi plant "Navoiazot".**		
Objective:	Recycling of collateral CO2 formed by manufacture of ammonia, for additional manufacture of carbamide with the purpose of increase of a production efficiency, save energy and CO2 emission, reduction of technological emissions.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Industrial processes	71,0	
Description:	On plant "Navoiazot" by manufacture of ammonia is formed 700 thousand tons per one year collateral CO2, which throw out in an atmosphere. The synthesis of carbamide is carried out from liquid ammonia and carbonic gas at temperature 183C and pressure 134 - 144 atmospheres. The project stipulates use collateral CO2 for manufacture of carbamide in volume up to 500,0 thousand tons т per one year.		
Expected Outputs:	Decrease of energy saving by manufacture of carbamide. Linkage of technological emissions of CO2. Additional manufacture of carbamide on 500,0 thousand tons per one year with reduction of CO2 emissions		
Required Technologies:	The new technological circuit TEC-ACES of manufacture of carbamide.		
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to lower emissions CO2 up to 220 thousand tons per one year.		

Project Category:	Manufacture of cement		Box № 31
Project Title	**Modernization of joint-stock company "Bekabadcement" with transfer of a technological line of manufacture of cement from a wet method on dry method.**		
Objective:	Reconstruction of manufacture of cement with the purpose of increase of productivity both energy saving and CO2 emission, reduction of technological emissions.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Industrial processes	84,4	
Description:	By the project is proposed the transfer to less power-intensive way of manufacture of cement. At a dry method of manufacture of clinker the chikhte break in pieces in dispersal powder, mixture, averaging and correcting make with a mix of powdery materials without participation of water, then the chikhte direct on sintering in the furnace. At existing, wet method of manufacture crushing of raw materials, their hashing, averaging and the correcting of a raw mix is carried out at the presence of the certain quantity of water, that requires additional energy on removal of water.		

Expected Outputs:	The reconstruction of manufacture will allow to increase volume of manufacture of cement on 450 thousand tons per one year with reduction of consumption of natural gas (on 1050 GKal by ton of cement) and electric power (at 27,9 kWt / hours on ton of cement).
Required Technologies:	The "know-how" technology on production of clinker by a dry method with use of system NSP (know-how) of the Japanese firm "IHI" at participation of the company "Mitsui".
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce CO2 emission on 193,0 thousand tons per one year.

Project Category:	**Manufacture of cement**	**Box№32**
Project Title	**Modernization of joint-stock company "Akhangarancement" with transfer of a technological line of manufacture of cement from a wet method on dry method**.	
Objective:	Reconstruction of manufacture of cement with the purpose of increase of productivity both energy saving and CO2 emission, reduction of technological emissions.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Industrial processes	87,2
Description:	By the project is proposed the transfer to less power-intensive way of manufacture of cement. At a dry method of manufacture of clinker the chikhte break in pieces in dispersal powder, mixture, averaging and correcting make with a mix of powdery materials without participation of water, then the chikhte direct on sintering in the furnace. At existing, wet method of manufacture crushing of raw materials, their hashing, averaging and the correcting of a raw mix is carried out at the presence of the certain quantity of water, that requires additional energy on removal of water.	
Expected Outputs:	The reconstruction of manufacture will allow to increase volume of manufacture of cement on 450 thousand tons per one year with reduction of consumption of natural gas (50%) and electric power (30%).	
Required Technologies:	The "know-how" technology on production of clinker by a dry method with use of system NSP (know-how) of the Japanese firm "IHI" at participation of the company "Mitsui".	
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce CO2 emission on 245,0 thousand tons per one year.	

Project Category:	**Manufacture of cement**	**Box№ 33**
Project Title	**Modernization of joint-stock company "Kuvasaicement" with transfer of a technological line of manufacture of cement from a wet method on dry method.**	
Objective:	Reconstruction of manufacture of cement with the purpose of increase of productivity both energy saving and CO2 emission,	

	reduction of technological emissions.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Industrial processes	87,2
Description:	By the project is proposed the transfer to less power-intensive way of manufacture of cement. At a dry method of manufacture of clinker the chikhte break in pieces in dispersal powder, mixture, averaging and correcting make with a mix of powdery materials without participation of water, then the chikhte direct on sintering in the furnace. At existing, wet method of manufacture crushing of raw materials, their hashing, averaging and the correcting of a raw mix is carried out at the presence of the certain quantity of water, that requires additional energy on removal of water.	
Expected Outputs:	The reconstruction of manufacture will allow to increase volume of manufacture of cement on 450 thousand tons per one year with reduction of consumption of natural gas (50%) and electric power (30%).	
Required Technologies:	The "know-how" technology on production of clinker by a dry method with use of system NSP (know-how) of the Japanese firm "IHI" at participation of the company "Mitsui".	
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce CO2 emission on 179,0 thousand tons per one year.	

Project Category:	**Building**	**Box № 34**
Project Title	**Modernization of manufacture of glassware in joint-stock company "Quartz"**	
Objective:	Modernization of manufacture of glassware by replacement of glass forming machines. Decrease of volumes of used fuel and CO2 emission.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Industrial processes	6,0
Description:	As a result of modernization the five current glass forming machines of the Russian manufacture VV-7 it is supposed to replace with two technological lines of German manufacture such as IC by general capacity 150 million pieces of glassware in per one year. It will allow to make glassware, answering to the world standards.	
Expected Outputs:	Increase of manufacture of empties in 1,3 times at same volume of glass masses with the appropriate reduction of volume of used fuel.	
Required Technologies:	The glass forming units such as IC-8 or IC-10 of German firms " Rekop AG ".	
Volume of Potential Reduction of GHG Emissions:	Decrease of CO2 emission on 15 thousand tons	

DISTRICT HEATING SUPPLY
(additional RAMBOLL's projects)

Project Category:	**District heating**		**Box № 35**
Project Title	*Reconstruction of district heating system "Machinostroitelnay"*		
Objective:	Demonstration of opportunities of increase of efficiency of use of fuel and energy resources by reconstruction both modernization of the boiler and network equipment of district heating system.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Municipal Heating Supply	0,148	
Description:	The decision of real reconstruction and modernization of small district heating system , including replacement of the boiler equipment, installation of solar panels, heat exchanger for generation of hot water, and also individual equipment, is developed. At modernization of boiler-houses the replacement of the existing equipment on import, having efficiency 92 % is offered. The technological decisions can be apply on other boiler of Uzbekistan.		
Expected Outputs:	The realization of the project will promote rational use of fuel and energy resources. The expected reduction of consumption of heat and hot water will make accordingly 25 % and 35 %. Emission of carbonic gas in an atmosphere on 403,3 tons CO2 per one year accordingly will decrease		
Required Technologies:	The import modern highly - effective boiler equipment, heat exchangers, thermostatic valves and heat allocaters on radiators.		
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce CO2 emission to 403,3 tons per one year.		

Project Category:	**District Heating**		**Box № 36**
Project Title	*The demonstration project for district heating system "TVRZ"*		
Objective:	Demonstration of opportunities of increase of efficiency of use of fuel and energy resources by reconstruction both modernization of the boiler and network equipment of middle district heating system.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Municipal heating supply	0,545	
Description:	The decision of real reconstruction and modernization of middle district heating system, including replacement of the boiler equipment, installation of solar panels, heat exchanger for heating and generation of hot water parallel pumps, and also individual equipment is developed. At modernization of boiler-houses the replacement of the existing equipment on highly effective import		

	is offered. The technological decisions can be apply on regional networks of heating supply of Uzbekistan.
Expected Outputs:	The realization of the project will promote rational use of fuel and energy resources. The expected reduction of consumption of heat and hot water will make accordingly 25 % and 32 %. Issue of carbonic gas in an atmosphere on 1624 tons CO2 per one year accordingly will decrease.
Required Technologies:	The import modern highly - effective boiler equipment, heat exchangers, parallel pumps, thermostatic valves and heat allocaters on radiators.
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce CO2 emission on 1,624 thousand tons per one year.

Project Category:	**District heating**		**Box № 37**
Project Title	*The demonstration project for district heating system "Heat Plant-8"* **(HP-8).**		
Objective:	Demonstration of opportunities of increase of efficiency of use of fuel and energy resources by reconstruction both modernization of the boiler and network equipment of large network of district heating system .		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Municipal heating supply	0,446	
Description:	The decision of real reconstruction and modernization of large network of district heating system , including maintenance service of a network, introduction of large-scale solar heat supply station, introduction of ring connection, closing of system, modernization of network and consumer devices, installation previously of isolated pipes is developed. At modernization of a network the replacement of the existing equipment and pipes on highly effective import is offered. The technological decisions can be apply on regional networks of heating supply of Uzbekistan.		
Expected Outputs:	The realization of the project will promote rational use of fuel and energy resources. The expected curtailment of production of heat and hot water will make 10 %. Emission of carbonic gas in an atmosphere on 11350 tons CO2 per one year accordingly will decrease.		
Required Technologies:	The import modern highly - effective network and boiler equipment for furnishing solar heat supply stations, consumer equipment.		
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce CO2 emission on 11,35 thousand tons per one year.		

Project Category:	District heating		Box № 38
Project Title	*The demonstration project for the large solar station of heating supply*		
Objective:	Demonstration of technology of solar collectors and auxiliaries for use in structure of large-scale station solar of heating supply.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Municipal heating supply	0,261	
Description:	Technology of solar heating is widely applied in the world and contains known components - valves, pumps, safety valves, heat exchangers. The collectors are optimized to climatic conditions. The decision supposes creation solar of heat supply station with the area of collectors 2000 m^2. The thermal productivity of panels makes 0,95 kWt / m^2. The technological decisions can be apply on boiler of Uzbekistan.		
Expected Outputs:	The realization of the project will promote replacement of organic fuel with a solar energy and saving of fuel and energy resources. Annual manufacture of heat and hot water will make 2,8 million kWt hours. Emission of carbonic gas in an atmosphere on 658 tons CO2 per one year accordingly will decrease.		
Required Technologies:	The import modern highly - effective solar collectors and complex of the equipment of solar heat supply station or organization of its manufacture in Uzbekistan.		
Volume of Potential Reduction of GHG Emissions:	Realization of the project will allow to reduce CO2 emission to 658 tons per one year.		

Project Category:	District heating		Box № 39
Project Title	**The demonstration project of a factory of the equipment of solar heating supply.**		
Objective:	The creation of a factory for assembly of solar panels intended for maintenance of the individual and collective owners of systems of solar heating supply.		
Country	**Sector**	**Budget, million US $**	
Uzbekistan	Municipal heating supply	0,155	
Description:	The project includes delivery of solar panels, furnishing for assembly, equipment for assembly, heat exchangers and internal network of pipes. At a local factory from imported furnishing and made on a place of heat insulate boxes and glass covers will be produced the modules of solar panels.		
Expected Outputs:	The realization of the project will promote development of national manufacture of solar panels, which use will promote replacement of organic fuel with a solar energy and saving of fuel and energy resources. Annual manufacture of heat and hot water will make 1,4 million kWt hours with 1000 m^2 of panels.		
Required Technologies:	The import of furnishing elements of solar panels and auxiliaries		

	or organization of its manufacture in Uzbekistan.
Volume of Potential Reduction of GHG Emissions:	The volume of reduction of issues makes 330 tons CO2 per one year with everyone 1000 m^2 of panels.

FORESTRY

Project Category:	Forest Shelter Belt	**Box № 40**
Project Title	**Development of forest shelter belt system at the irrigated lands to stabilize the agriculture landscapes in Besharyk district, Fregana province, the Republic of Uzbekistan**	
Objective:	Stabilization of the level of soil fertility of used lands due to removing soil erosion caused by wind and reducing the level of mineral ground waters under pressure of bio drainage capacity of plantations. Increase of carbon dioxide sinks in forestry sector.	
Country	**Sector**	**Budget, million US $**
Uzbekistan	Land Use Change and Forestry	0,12
Description:	In arid zone of Uzbekistan the farming is possible at irrigated lands only. The applied way of irrigation increases the level of mineralized ground waters and causes secondary soil salinity. Ploughing land increased the soil erosion caused by wind. It reduces soil fertility that potentially will result in withdrawal of the lands from the agriculture turnover. Development of forest shelter belts will prevent the soil erosion caused by wind, reduce the level of ground waters, and delay the reduction of soil fertility. The plantation forestry has a great productivity in terms of irrigation and is the major sink of carbon dioxide.	
Expected Outputs:	Transformation of 350-hectare irrigated agriculture land inclined to degradation in self-regulating forest-agriculture landscape due to developing 10.5 hectares of forest shelter belts, 4.5 hectares of protective forestry along irrigation-drainage and road networks and 3 hectares of plantations of rapid growing woods. Increase of land productivity at the expense of agriculture crops and fitomass of forest shelter belts. Development of considerable reservoir for carbon dioxide sinks with accrued capacity during 30 –100 years.	
Required Technologies:	The national way to develop a regulative system of forest shelter belts along irrigation and drainage networks, as well as plantations of rapid growing woods.	
Volume of Potential Reduction of GHG Emissions:	The expected average sinks equal to 200 tons of CO_2 per 1 hectare yearly with accrued balance during 30 - 100 years depending on type of woods; following the project recommendations it will absorb up to 3600 tons of CO_2.	

ANNEX 2

Indicators of Economic Efficiency of Transfer Technology Projects

№	Technology	Investment per unit of reduced emission,$/tons	Period of repay	NPV (for 15 years) thousand $	IRR (for 15 years)	EIRR (for 15 years)
1	Reconstruction of Navoi Heat Power Plant (HPP) by installation of steam-gas unit with capacity of 350 MWt	12	13	-42130	6.8%	13.5%
2	Reconstruction of electric unit on Tashkent Heat Plant by installation of Gas Turbine Unit (GTU) with capacity of 370 MWt	12	14	-49631	6.1%	13.0%
3	Installation of Gas Turbine Unit (GTU) with Utilizing Boiler (with capacity of 64 MWt) at the Tashkent Heat Power Plant	5	6	16874	21.7%	34.9%
4	Reconstruction of Joint-Stock Venture “Bukharaenergomarkaz” by installation of GTU with capacity of 62 MWt	10	11	-3591	8.5%	26.8%
5	Hydroelectric power station on the river Pskem by capacity 404 MWt	8		-174645	0.5%	2.8%
6	Reconstruction of Mubarek Heat Power Plant (HPP) by installation of GTU and utilizing boilers	11	10	846	10.1%	14.5%
7	Introduction of energy-saving complex on Talimarjan power station based on Detander- Generator aggregate DGA-5000	13	9	128	10.9%	35.0%
8	Utilization of Accompanying Gas of the Kokdumalak Oil and Condensed Gas Deposit at the Mubarek Oil-and-Gas Processing Plant	2	14	-16977	6.6%	18.1%
9	Installation pre-cleaning of departing gases by a method SCOT on Mubarek Oil-and-Gas Processing Plant	6	*)	-19645	-1.9%	6.1%
10	Assembling of system of the automatic control of structure of departing gases and loading, proportion of hydrogen and oxygen on Mubarek Oil-and-Gas Processing Plant	1	6	595	21.3%	130.3%
11	Installation of pre-cleaning of departing gases by a method adsorption on a cold layer of the catalyst on Mubarek Oil-and-Gas Processing Plant	1	13	-406	7.1%	50.7%
12	Gas fractional unit on Fergana Oil-and-Gas Processing Plant	12	9	16379	13.3%	16.7%
13	Reconstruction of Flare System of the Main Units of the Oil and Gas Enterprise “Shurtanneftegaz”	6.3	*)	-50491	-6.5%	9.3%
14	The second step of installation of sulfur extraction by a method of direct oxidation on Mubarek Oil-and-Gas Processing Plant	2	12	-201	6.0%	56.6%
15	Reconstruction of torch system on Mubarek Oil-and-Gas Processing Plant	6	*)	-46970	-5.5%	11.5%
16	Reconstruction of two heat boiler-houses on Mubarek Oil-and-Gas Processing Plant	2	8	450	13.0%	34.7%
17	Reconstruction of compressor station KS-0 in Mubarek city	23	*)	-50273	-4.4%	-0.8%

18	Reconstruction of Compressing Stations of the Main Units at the Gazli Deposit	16	*)	-73204	-2.1%	0.1%
19	Reduction of outflow of gas at compressor stations CS-2 and CS-3 in Company "Uztransgas"	0.15	7	2069	18.2%	45.8%
20	Reduction of natural gas losses at the lineal part of main gas pipeline	11	*)	-49231	-2.7%	-2.1%
21	Utilization of Domestic Waste as the Low-Calorie Fuel (Incinerating Plant in Samarkand City)	14.0	*)	-14042	4.6%	16.5%
22	***Construction of a wind-driver power station WPS-6***	17	*)	-3219	1.3%	8.8%
23	Technology of Electric and Heat Generation on the Base of a Biogas from the Surplus Active Sludge at the Water Treatment Plant of Tashkent City	27.9	12	-1416	6.8%	20.5%
24	Reconstruction of manufacture of carbamide on Chirchik plant "ELECTROCHIMPROM”	24	*)	-25376	2.3%	17.1%
25	Reconstruction of carbamide manufacture on Fergana plant "AZOT“	26	7	29848	16.7%	34.7%
26	Construction of the new unit of ammonia on Chirchik plant “ELECTROCHIMPROM”	64	*)	-107140	2.5%	1.8%
27	Reconstruction of the large-weighty of the unit of ammonia on Fergana plant "AZOT"	4.7	5	21289	24.3%	57.4%
28	Reconstruction of the large-weighty the unit of ammonia on Chirchik plant "ELECTROCHIMPROM"	4.7	5	21389	24.3%	56.9%
29	Construction of energy unit on Navoi plant "NAVOIAZOT"	20	9	18850	12.3%	16.5%
30	Construction of new manufacture of carbamide on Navoi plant "NAVOIAZOT"	16	8	26724	16.1%	19.4%
31	Modernization of joint-stock company "BEKABADCEMENT" with transfer of technological line of cement production from a wet method on dry method	9	11	-144	10.0%	13.1%
32	Modernization of joint-stock company "AKHANGARANCEMENT" with transfer of technological line of cement production from a wet method on dry method	7	*)	-47722	0.9%	3.9%
33	Modernization of joint-stock company "KUVASAYCEMENT" with transfer of technological line of cement production from a wet method on dry method	10	*)	-50807	0.3%	2.5%
34	Modernization of manufacture of glassware in joint-stock company "Quartz"	16	*)	-3680	-0.8%	2.1%

Note: *) – period of repay beyond the forecast period equals to 15 years

Acronyms and Abbreviations

AS RoU	Academy of Sciences of the Republic of Uzbekistan
GDP	Gross domestic product
RES	Renewable energy sources
WMO	World Meteorological Organisation
WHCMS	World Hydrological Cycle Monitoring System
WDF	Wind-driven facility
SCST	State Committee for Science and Technology
Glavhydromet	Chief Administration for Hydro-Meteorology of RoU
GTS	Global Telecommunications System
HEPP	Hydraulic energy power plant
SREPP	State regional electric power plant
GTU	Gas turbine unit
GEF	Global Environmental Facility
GCMS	Global Climate Monitoring System
CPP	Condensation power plant
IPCC	Intergovernmental Panel on Climate Change
GR	Gas refinery
GCM	General circulation model
NHMS	National Hydro-Meteorological Service
OGRF	Oil and gas refining facility
NMC	Non-methane carbons
PEC	Permissible emission ceiling
PA	Production amalgamation
GHG	Greenhouse gas
UNDP	United Nations Development Programme
UNCCC	UN Convention on Climate Change
RoU	Republic of Uzbekistan
CARHMI	Central Asian Research Hydro-Meteorological Institute
TEPP	Thermoelectric power plant
HP	Heating plant
SDW	Solid domestic wastes
SGU	Steam-and-gas unit
Uzavtotrans	‘Uzavtotrans’ State Joint Stock Company
Uzbekneftegaz	‘Uzbekneftegaz’ National Corporation
GWT	Groundwater table
GTU	Gas pre-treatment unit
IGTU	Integrated gas treatment unit
OTU	Oil treatment unit
EFT	Environment friendly technology

Chemical symbols

CH_4	Methane
CO_2	Carbon dioxide
N_2O	Nitrous oxide
NH_3	Ammonia
NO_x	Nitric oxide

Units of Measure

º C	degree Centigrade
ha	hectare
Gcal	Great calorie
HPa	Hectapascal
W	Watt
W/m^2	Watt per square metre
kW/h	Kilowatt (10^3 watt) hour
mm	millimetre
cm	centimetre
m	metre
km	kilometre
km^2	square kilometre
Kcal/kg	Kilo-calories per kilogram
Kg/ha	Kilogram per hectare
m/sec	metres per second
m^3	cubic metre
m^3/sec	cubic metres per second
m^2	square metre
Mw	Megawatt
MJ	Megajoule
MJ/ m^2	Megajoule per square metre
PJ	Pentajoule
t	ton
c/ha	centner (100 kg) per hectare

Terminological Reference

Energy	All kinds of fuel and energy resources if a resource is not specified
Oil	Crude oil and gas condensate as well as products obtained from them if not specified otherwise

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